

Consumer Guide to Green Energy Choices

Appendices

Prepared by

Leonardo Academy's Cleaner and Greenersm Program

March 15, 1999

Contact Information:

Leonardo Academy Inc.
1526 Chandler Street
Madison, WI 53711

Telephone: 608.280.0255
FAX: 608.255.7202
Email info@leonardoacademy.org
Web Sites: www.cleanerandgreener.org
www.leonardoacademy.org

Appendix A

Summary of the Model Approach Used to Calculate the Incremental Cost and Emission Reductions from the Wisconsin Demand-Side Options Database (WDOD) Pool of Energy Efficiency and Fuel Switching Measures

The energy efficiency study used a consumer perspective analysis to identify the energy efficiency and fuel switching measures with the lowest net life cycle cost per ton of carbon dioxide (CO₂) reduced. This was done using the following steps:

1. Net life cycle costs were calculated by subtracting the incremental savings over the life of an efficient measure from the incremental capital and operating costs above those of the standard replacement technology. Incremental energy savings were calculated by multiplying electricity (kilowatt-hour) and capacity (kilowatt) savings by the avoided cost of energy to end use consumers. This cost ranged from about five cents to seven cents per kilowatt-hour dependent upon which sector was being analyzed.
2. CO₂-equivalent emission reductions were calculated for each measure by multiplying electricity savings by the average emission factor for generating electricity in Wisconsin. (WDNR, 1998).

The analysis was only carried out to the incremental cost and saving level. The end use analysis looked at both efficiency and fuel switching measures to reduce electricity and natural gas consumption in the Residential, Industrial, Commercial & Institutional, and Agriculture sectors. Alternate model scenarios were also developed based on different levels of estimated emission costs for NO_x and mercury which may be levied against energy producers in the future. This was done to study the effect which increased emission costs on energy providers have upon the cost effectiveness of energy efficiency measures. The consumer cost ranking for this process per CO₂-equivalent saved (\$ per ton) are shown by individual efficiency measures at the end of Appendix A.

Cost Screening Method

The objective of the cost screening analysis was to determine the most cost-effective reduction measure or combination of measures for each end use application. This was done in a two step process by first determining the marginal cost and emission impact of each measure versus the expected base condition. Then, based on this information, the measures with the highest reduction potential (CO₂-ton/yr) were ranked per ton of CO₂ reduction.

Measure Costs

The total marginal cost and emission impacts of reduction measures were determined relative to the energy provider meeting a specific end use energy load requirement. The total cost is then the sum of the incremental costs and benefits of the measure.

$$\text{Measure Costs (\$)} - \text{Measure Benefits (\$)} = \text{Total Measure Costs (\$)}$$

The costs addressed for end use measures are shown in Table A.1. These costs were levelized over the measure's lifetime using a 5.5% discount rate to yield the annual cost. The analysis does not discount for inflationary impacts and presents all levelized costs in 1993 constant dollars. The fixed costs for end use measures including capital, installation, and capacity value costs were levelized using a fixed charge rate based on the lifetime of the option. This calculation is:

$$\text{Annual Fixed Cost (\$/yr)} = \text{Initial Fixed Cost (\$)} * \text{Fixed Charge Rate (\%)}$$

The fixed charge rate is calculated using the Electric Power Research Institute's CCLN program. This program determines the fixed charge rate for levelizing the fixed costs of new power generation facilities based on typical utility debt amortization practices, the assumed discount rate, lifetime of the measure, and various other factors specific to the industry. This assumes that all end use costs are assumed by the Electric Utility instead of the looking at the cost in terms of repaying or providing an equivalent rebate for debt incurred under consumer economic conditions.

Table A.1 Measure Costs in Screening Analysis

End Use Measures
Capital & Installation (\$/unit) - variable
O&M (\$/unit-yr) - variable
Fuel: Electricity (\$/kWh) Natural Gas (\$/MMBtu)
Capacity Value (\$/kW)
Emissions: SO ₂ (\$/ton) = \$100

The capital and installation costs were obtained from the Wisconsin Center for Demand Side Research's database (ECW, 1994) of end use energy efficiency and reduction measures. The variable cost of operation and maintenance (O&M), fuel, and emissions are presented on an annual basis and are usually related to the operational duration or load. These costs were levelized using the following method:

$$\text{Annual Levelized Cost (\$/yr-unit)} = \text{Initial Annual Cost (\$/yr-unit)} * \text{Levelization Factor}$$

The calculation of the levelization factor follows the procedure outlined in the EPRI Technical Assessment Guide (EPRI, 1994).

$$\text{Levelization Factor} = K * (1 - K^n) / [An * (1 - K)]$$

$$An \text{ (present value factor)} = [(1 + r\text{drate})^n - 1] / [r\text{drate} * (1 + r\text{drate})^n]$$

$$K \text{ (escalation factor)} = (1 + \text{escrate}) / (1 + r\text{drate})$$

$$\text{escrate (\%)} = [(1 + \text{escrate}) * (1 + \text{inflation rate})] - 1$$

where: rdrate = real discount rate.
 escrate = real escalation rate (@ inflation = 0), or actual escalation rate (@ inflation > 0).
 inflation = annual inflation rate, when = 0 then analysis is in real constant dollars, when >
 0 then analysis is in terms of current dollars.
 n = lifetime of the option or unit in years.

The annual fuel costs were levelized using escalation rates specific to each end use and utility sectors as projected by the U.S. Department of Energy (EIA, 1998). Sulfur Dioxide emissions were monetized at \$100 per ton in every model scenario to reflect approximate current values in the trading market at the time of the analysis in early 1998. Current values of sulfur dioxide emissions are closer to \$200 per ton in March, 1999 which would increase the cost savings from energy efficiency measures. The control of NOx and Hg was evaluated at different levels to study the effect which increased emission costs on energy providers have upon the cost effectiveness of energy efficiency measures. NOx emission cost levels of \$850, \$1,700, and \$3,400 and Hg emission costs of \$30,000 per ton were studied. The control of particulates can also be substantial but was not included in this evaluation.

Electric Energy and Capacity Costs

The delivery of energy to the end user usually involves two types of cost. The first is the actual cost of the energy and the second is the cost of the infrastructure or available capacity needed to meet the peak energy requirement (demand).

Electric energy savings from end use measures were viewed as energy bill savings to the end consumer. The calculation of levelized electric cost savings is:

$$\text{Electric Cost Savings (\$/yr)} = \text{Electric Savings (kWh/yr)} * \text{Levelized Cost of Delivered Energy to the consumer (\$/kWh-d)}$$

Theoretically an option could increase the electricity consumption while reducing consumption of other fuels. In this case, electricity is valued at the added cost that would be seen by the end user in 1993 dollars (WEB, 1994).

$$\text{Electric Cost Increase (\$/yr)} = \text{Electric Savings (kWh/yr)} * \text{End Use Electric Cost (\$/1993/kWh)}$$

To calculate the capacity value for an end use option, the amount of capacity made available to the system must first be determined. It was calculated using Demand-to-Energy ratios (D/E) determined by the Wisconsin Center for Demand-Side Research (WAU, 1994). The calculation for end use capacity savings is:

$$\text{Option Capacity Savings (kW)} = \text{Energy Savings (kWh/yr)} * \text{D/E Ratio of End Use (kW/kWh)}$$

A combustion turbine is used for meeting peak load requirements because it is readily available whenever the peak demand occurs. The capacity savings or availability does not always coincide with time of peak load requirement. Therefore, this amount of capacity must be adjusted to reflect

its availability. This availability is represented by a Capacity Contribution Index (CCI). It is considered as the average operating diversified watts of the unit divided by the connected load. The ratio of the option CCI to the combustion CCI can then be used to put the available capacity in terms of equivalent combustion turbine capacity (CT-equiv). This calculation is given as:

$$\text{Capacity Savings (CT-equiv. kW)} = \text{Option Capacity (kW/yr)} * \text{CCI option} / \text{CCIct}$$

The value of available capacity can the be calculated by:

$$\text{Capacity Value (\$)} = \text{Capacity Savings (CT-equiv. kW)} * \text{CT Capacity Value (\$/kW)}$$

Measure Emissions

The marginal emissions are the incremental emissions from the net difference in consumption of electricity and other applicable fuels (natural gas, solar, etc.). The electricity emissions for CO₂, SO₂, and NO_x are based on Wisconsin utility system-wide average emission factors per delivered kilowatt-hour (kWh-d).

Table A.2 End Use Measure Emission Factors.

Pollutant	Electricity (lbs/kWh-d)	Natural Gas (lbs/MMBtu)
CO ₂ -equivalents	1.81	130
SO ₂	0.00595	0.006
NO _x	0.0045	0.45
Hg	3.20e-08	0.0000

Note: Emissions factors, shown in Table A.2, are comprehensive for emissions from the production and distribution through end use of the fuel.

Sources

Energy Center of Wisconsin. Wisconsin Demand-Side Options Database (WDOD), 1994.

Electric Power Research Institute (EPRI), Technical Assessment Guide, Volume II, 1994.

Energy Information Administration (EIA), State Energy Price and Expenditure Report 1995, DOE/EIA-0376(95), August 1998.

Wisconsin Associated Utilities (WAU), Statewide Technical and Economic Potential, Advance Plan 7 Technical Support Document D12, 1994.

Wisconsin Associated Utilities (WAU), Power Supply, Advance Plan 7 Technical Support Document D24, 1994.

Wisconsin Department of Natural Resources. Wisconsin Greenhouse Gas Emission Reduction Cost Study, Report 3, Emission Reduction Cost Analysis, 1998.

Appendix A1

List of Specific Efficiency Measures Ranked by Their Incremental Cost of Reducing Greenhouse Gas Emissions

Table A.3 The Net Cost of Reducing Greenhouse Gas Emissions, By Measure from an End Use Consumer Perspective

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	Net Real CO ₂ -equiv Savings per unit per year (tons)	Consumer Costs per CO ₂ -equiv Saved (\$/ton)
Residential	Space Cooling	Central A/C	Single Family	Efficient Heat pump	0.12	(\$1,266.97)
Residential	Space Cooling	Central A/C	Multi-family	Efficient Heat pump	0.10	(\$1,216.18)
Residential	Space Cooling	Central A/C	Single Family	Eff. Open Loop Ground Source Heat Pump	0.13	(\$1,005.72)
Residential	Space Cooling	Central A/C	Multi-family	Eff. Open Loop Ground Source Heat Pump	0.11	(\$937.48)
Residential	Space Cooling	Central A/C	Single Family	Eff. Closed Loop Ground Source Heat Pump	0.17	(\$471.69)
Residential	Space Cooling	Central A/C	Single Family	Whole-House fan	0.42	(\$418.49)
Residential	Space Cooling	Central A/C	Multi-family	Eff. Closed Loop Ground Source Heat Pump	0.14	(\$366.23)
Residential	Space Cooling	Central A/C	Single Family	2-speed Ground Source Heat Pump	0.29	(\$218.37)
Residential	Freezing	Average Freezer	Multi-family	Eff. Upright Freezer (15.5-17.4ft ³)	0.13	(\$216.08)
Residential	Freezing	Average Freezer	Single Family	Eff. Upright Freezer (15.5-17.4ft ³)	0.13	(\$208.07)
Residential	Space Cooling	Central A/C	Single Family	2-speed Ground Source Heat Pump	0.29	(\$206.92)
Residential	Space Heating	Heat Pump	Single Family	Dual Fuel Heating HPH	0.67	(\$198.21)
Industrial	Refrigeration	Refrig. Base, no 1st cost	All	Cold Start Controls	0.19	(\$186.50)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Programmable thermostat	0.43	(\$185.92)
Residential	Space Heating	Heat Pump	Single Family	Gas Furnace	0.67	(\$181.80)
Industrial	Refrigeration	Refrig. Base, no 1st cost	All	Improved Fridge Doors	0.19	(\$177.13)
Residential	Space Heating	Heat Pump	Multi-family	Gas Furnace	0.39	(\$166.85)
Residential	Space Heating	Heat Pump	Multi-family	Efficient Heat pump	0.23	(\$139.95)
Residential	Freezing	Freezer	Multi-family	Eff. Upright Freezer (17.5-19.4ft ³)	0.09	(\$137.04)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Programmable thermostat	0.88	(\$135.69)
Residential	Freezing	Freezer	Single Family	Eff. Upright Freezer (17.5-19.4ft ³)	0.10	(\$132.85)
Residential	Space Heating	Heat Pump	Multi-family	Dual Fuel Heating HPH	1.63	(\$124.51)
Commercial	Lighting	High Efficiency Fluorescent	Miscellaneous	HE Fluor. w/Reflectors	0.79	(\$119.08)
Residential	Freezing	Freezer	Multi-family	Efficient Chest Freezer (15ft ³)	0.20	(\$109.45)
Residential	Freezing	Freezer	Single Family	Efficient Chest Freezer (15ft ³)	0.21	(\$108.53)
Industrial	Refrigeration	Refrigeration Base Case	All	Building Envelope	0.19	(\$108.33)
Commercial	Lighting	Incandescent Spots & Floods	Grocery	Metal Halide	40.47	(\$102.37)
Commercial	Lighting	Incandescent Spots & Floods	Restaurant	Metal Halide	10.96	(\$100.48)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Lighting	High Efficiency Fluorescent	Lodging	HE Fluor. w/Reflectors	0.57	(\$99.22)
Commercial	Lighting	High Efficiency Fluorescent	Health	HE Fluor. w/Reflectors	1.90	(\$98.89)
Residential	Space Cooling	Central A/C	Single Family	2-speed Ground Source Heat Pump (slinky)	0.29	(\$98.53)
Commercial	Lighting	Incandescent Spots & Floods	Warehouse	Metal Halide	7.71	(\$98.45)
Commercial	Lighting	Incandescent Spots & Floods	Health	Metal Halide	19.55	(\$97.35)
Commercial	Lighting	High Efficiency Fluoresce	College	HE Fluor. w/Reflectors	1.17	(\$97.18)
Commercial	Lighting	Incandescent Spots & Floods	College	Metal Halide	12.06	(\$96.80)
Commercial	Lighting	High Efficiency Fluoresce	School	HE Fluor. w/Reflectors	1.06	(\$96.72)
Commercial	Lighting	Incandescent Spots & Floods	School	Metal Halide	11.16	(\$96.20)
Commercial	Lighting	High Efficiency Fluorescent	Warehouse	HE Fluor. w/Reflectors	0.75	(\$95.92)
Commercial	Lighting	High Efficiency Fluorescent	Restaurant	HE Fluor. w/Reflectors	1.07	(\$94.82)
Commercial	Lighting	High Efficiency Fluorescent	Retail	HE Fluor. w/Reflectors	1.87	(\$94.82)
Commercial	Lighting	High Efficiency Fluorescent	Office	HE Fluor. w/Reflectors	1.59	(\$94.75)
Residential	Freezing	Freezer	Multi-family	Eff. Chest Freezer MD(15-17.5ft3)	0.17	(\$94.65)
Commercial	Lighting	Incandescent Spots & Floods	Miscellaneous	Metal Halide	8.14	(\$94.59)
Residential	Freezing	Freezer	Single Family	Eff. Chest Freezer MD(15-17.5ft3)	0.18	(\$94.26)
Commercial	Lighting	High Efficiency Fluorescent	Grocery	HE Fluor. w/Reflectors	3.99	(\$94.18)
Commercial	Lighting	Incandescent Spots & Floods	Lodging	Metal Halide	5.83	(\$91.79)
Industrial	Refrigeration	Refrig. Base, no 1st cost	All	Control System	0.56	(\$89.66)
Commercial	Lighting	Standard Incandescent	Grocery	Screw-In Fluorescent	30.92	(\$86.73)
Residential	Space Heating	Heat Pump	Single Family	Efficient Heat Pump	0.37	(\$86.70)
Residential	Refrigeration	Refrigerator Primary AVG.	Multi-family	Best current Refrig-18ft3-Top Freezer	0.34	(\$86.25)
Residential	Refrigeration	Refrigerator Primary AVG.	Multi-family	Golden Carrot Refrig 22ft3	0.22	(\$86.25)
Residential	Refrigeration	Refrigerator autodefrost AVG.	Single Family	Golden Carrot Refrig 22ft3	0.77	(\$86.25)
Residential	Refrigeration	Refrigerator Primary AVG.	Single Family	Golden Carrot Refrig 22ft3	0.37	(\$86.25)
Residential	Refrigeration	Refrigerator Prim. & Sec. Avg	Single Family	Golden Carrot Refrig 22ft3	1.07	(\$86.25)
Residential	Refrigeration	Refrigerator Primary AVG.	Single Family	Best current Refrig-18ft3-Top Freezer	0.49	(\$86.25)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Office	2-8' HEF & 1 HEB & Refl.	1.45	(\$85.80)
Commercial	Lighting	Standard Incandescent Bas	Retail	Screw-In Fluorescent	14.50	(\$85.71)
Residential	Refrigeration	Refrigerator Secondary AVG.	Multi-family	Remove Refrigerator	0.66	(\$85.53)
Residential	Refrigeration	Refrigerator Secondary AVG.	Single Family	Remove Refrigerator	0.70	(\$85.53)
Residential	Space Heating	Heat Pump	Single Family	Efficient Gas Furnace	1.01	(\$84.20)
Commercial	Lighting	Standard Incandescent	Health	Screw-In Fluorescent	14.76	(\$83.75)
Agricultural	Other/General	Engine Heater w/o Timer	All Farms	Engine Heater with Timer	1.87	(\$82.41)
Commercial	Lighting	Standard Incandescent	College	Screw-In Fluorescent	9.11	(\$82.13)
Commercial	Lighting	Standard Incandescent	School	Screw-In Fluorescent	8.23	(\$81.77)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Lighting	Standard Incandescent	Office	Screw-In Fluorescent	12.31	(\$81.03)
Commercial	Lighting	Standard Fluorescent	Lodging	HE Fluor. w/Reflectors	0.92	(\$80.85)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Grocery	2-8' HEF & 1 HEB & Refl.	3.64	(\$80.05)
Commercial	Lighting	Standard Incandescent	Lodging	Screw-In Fluorescent	4.40	(\$79.24)
Commercial	Lighting	Standard Fluorescent	School	HE Fluor. w/Reflectors	1.73	(\$79.00)
Commercial	Lighting	Standard Fluorescent	College	HE Fluor. w/Reflectors	1.91	(\$78.84)
Commercial	Lighting	Standard Fluorescent	Office	HE Fluor. w/Reflectors	2.58	(\$77.93)
Commercial	Lighting	Standard Fluorescent	Retail	HE Fluor. w/Reflectors	3.04	(\$77.67)
Commercial	Lighting	Standard Fluorescent	Warehouse	HE Fluor. w/Reflectors	1.22	(\$77.62)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Restaurant	2-8' HEF & 1 HEB & Refl.	0.98	(\$77.40)
Commercial	Lighting	Standard Fluorescent	Restaurant	HE Fluor. w/Reflectors	1.73	(\$77.19)
Commercial	Lighting	Standard Fluorescent	Health	HE Fluor. w/Reflectors	3.09	(\$77.05)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Retail	2-8' HEF & 1 HEB & Refl.	1.71	(\$77.00)
Commercial	Lighting	Standard Fluorescent	Grocery	HE Fluor. w/Reflectors	6.48	(\$76.99)
Commercial	Lighting	Standard Incandescent	Warehouse	Screw-In Fluorescent	5.82	(\$76.85)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Health	2-8' HEF & 1 HEB & Refl.	1.74	(\$76.37)
Commercial	Lighting	Standard Incandescent	Restaurant	Screw-In Fluorescent	8.27	(\$75.86)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Warehouse	2-8' HEF & 1 HEB & Refl.	0.69	(\$74.31)
Commercial	Lighting	Standard Incandescent	Miscellaneous	Screw-In Fluorescent	6.14	(\$74.26)
Residential	Freezing	Standard Freezer	Single Family	Eff. Chest Freezer MD(17.5-19.4ft3)	0.15	(\$74.20)
Commercial	Lighting	Standard 8' Fluor. Base	Grocery	2-8' HEF & 1 HEB & Refl.	5.70	(\$74.15)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Miscellaneous	2-8' HEF & 1 HEB & Refl.	0.72	(\$74.01)
Agricultural	Stock Watering	Elect. Heated Waterer	All Farms	Energy-Free Waterer	0.68	(\$73.99)
Commercial	Lighting	Standard 8' Fluor. Base	Office	2-8' HEF & 1 HEB & Refl.	2.27	(\$73.57)
Residential	Freezing	Standard Freezer	Multi-family	Eff. Chest Freezer MD(17.5-19.4ft3)	0.14	(\$73.50)
Residential	Clothes Drying	Electric Dryer: Typical New	Single Family	Gas Dryer: 1994 min eff. std	0.71	(\$72.87)
Commercial	Lighting	Standard 8' Fluor. Base	Restaurant	2-8' HEF & 1 HEB & Refl.	1.53	(\$72.24)
Commercial	Lighting	Standard 8' Fluor. Base	Retail	2-8' HEF & 1 HEB & Refl.	2.67	(\$71.73)
Commercial	Water Heating	Base Water Heat	Restaurant	Heat Pump Water Heater	2.74	(\$71.47)
Commercial	Lighting	Standard 8' Fluor. Base	Health	2-8' HEF & 1 HEB & Refl.	2.72	(\$71.33)
Commercial	Refrigeration	Refrigeration Base Case	Grocery	Head Pressure Controls	1.90	(\$70.92)
Commercial	Space Heating	All Space Heating Base	School	Temperature Set-back	1.31	(\$70.92)
Commercial	Space Heating	All Space Heating Base	Miscellaneous	Temperature Set-back	1.26	(\$70.84)
Commercial	Space Heating	All Space Heating Base	Grocery	Temperature Set-back	1.26	(\$70.84)
Commercial	Lighting	Standard 8' Fluor. Base	Miscellaneous	2-8' HEF & 1 HEB & Refl.	1.13	(\$70.75)
Commercial	Space Heating	All Space Heating Base	Health	Temperature Set-back	1.12	(\$70.54)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Space Heating	All Space Heating Base	Office	Temperature Set-back	1.10	(\$70.48)
Commercial	Cooking	Electric Cooking Base	School	Gas Cooking	0.39	(\$70.47)
Commercial	Cooking	Electric Cooking Base	Lodging	Gas Cooking	0.39	(\$70.47)
Commercial	Cooking	Electric Cooking Base	Health	Gas Cooking	0.66	(\$70.47)
Commercial	Cooking	Electric Cooking Base	Grocery	Gas Cooking	0.55	(\$70.47)
Commercial	Cooking	Electric Cooking Base	Retail	Gas Cooking	0.28	(\$70.47)
Commercial	Cooking	Electric Cooking Base	Miscellaneous	Gas Cooking	0.28	(\$70.47)
Commercial	Cooking	Electric Cooking Base	Office	Gas Cooking	0.33	(\$70.46)
Commercial	Cooking	Electric Cooking Base	College	Gas Cooking	0.44	(\$70.46)
Commercial	Cooking	Electric Cooking Base	Restaurant	Gas Cooking	8.18	(\$70.46)
Commercial	Cooking	Electric Cooking Base	Warehouse	Gas Cooking	0.33	(\$70.46)
Commercial	Space Heating	All Space Heating Base	Restaurant	Temperature Set-back	1.05	(\$70.34)
Commercial	Space Heating	All Space Heating Base	Retail	Temperature Set-back	0.93	(\$69.96)
Commercial	Space Heating	Electric Heating Base	School	High Efficiency Gas	7.22	(\$69.90)
Commercial	Space Heating	Electric Heating Base	Grocery	High Efficiency Gas	6.98	(\$69.86)
Commercial	Space Heating	Electric Heating Base	Miscellaneous	High Efficiency Gas	6.98	(\$69.86)
Commercial	Space Heating	Electric Heating Base	Health	High Efficiency Gas	6.20	(\$69.74)
Commercial	Space Heating	Electric Heating Base	Office	High Efficiency Gas	6.08	(\$69.72)
Commercial	Space Heating	All Space Heating Base	Warehouse	Temperature Set-back	0.85	(\$69.67)
Commercial	Space Heating	Electric Heating Base	Restaurant	High Efficiency Gas	5.79	(\$69.66)
Commercial	Space Heating	Electric Heating Base	Retail	High Efficiency Gas	5.13	(\$69.51)
Commercial	Lighting	Standard 8' Fluor. Base	Warehouse	2-8' HEF & 1 HEB & Refl.	1.07	(\$69.45)
Commercial	Space Heating	All Space Heating Base	Lodging	Temperature Set-back	0.80	(\$69.43)
Commercial	Space Heating	Electric Heating Base	Warehouse	High Efficiency Gas	4.71	(\$69.39)
Commercial	Space Heating	Electric Heating Base	Lodging	High Efficiency Gas	4.41	(\$69.29)
Commercial	Space Heating	Electric Heating	College	High Efficiency Gas	3.76	(\$69.01)
Commercial	Space Heating	All Space Heating Base	College	Temperature Set-back	0.68	(\$68.75)
Residential	Clothes Drying	Electric Dryer: Typical New	Multi-family	Gas Dryer: 1994 min eff. standard	0.51	(\$68.60)
Commercial	Lighting	4-8' HEF & 2 HEB Base	College	2-8' HEF & 1 HEB & Refl.	1.07	(\$68.42)
Commercial	Water Heating	Base Water Heat	Lodging	Heat Pump Water Heater	0.95	(\$68.40)
Commercial	Water Heating	Base Water Heat	Health	Heat Pump Water Heater	0.95	(\$68.40)
Commercial	Space Heating	All Space Heating Base	Grocery	Air-to-Air Heat Exchanger	5.73	(\$68.27)
Commercial	Refrigeration	Refrigeration Base Case	Grocery	High Efficiency Compressor	2.54	(\$67.92)
Commercial	Lighting	Standard Fluorescent Base	Miscellaneous	HE Fluor. w/Reflectors	1.29	(\$67.80)
Commercial	Space Heating	All Space Heating Base	Restaurant	Air-to-Air Heat Exchanger	4.75	(\$67.12)
Commercial	Lighting	4-8' HEF & 2 HEB Base	School	2-8' HEF & 1 HEB & Refl.	0.97	(\$66.80)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Water Heating	Base Water Heat	College	Heat Pump Water Heater	0.71	(\$66.73)
Agricultural	Water Heating	80-gal Elec. Water Heater	Dairy Farms	High eff. 80-gal Water Heater	0.56	(\$66.57)
Residential	Refrigeration	Refrigerator: autodefrost avg.	Single Family	Adaptive Defrost-18ft3 (no CFCs)	0.94	(\$66.41)
Commercial	Space Heating	All Space Heating Base	Retail	Air-to-Air Heat Exchanger	4.21	(\$66.26)
Commercial	Ventilation	All Ventilation Base	Health	Reduce Fan Power	0.62	(\$66.00)
Commercial	Lighting	Standard 8' Fluor. Base	College	2-8' HEF & 1 HEB & Refl.	1.68	(\$65.80)
Commercial	Lighting	Standard 8' Fluor. Base	School	2-8' HEF & 1 HEB & Refl.	1.52	(\$65.78)
Commercial	Build Envelope	Base Envelope	Grocery	Eff Build Envelope	3.01	(\$65.72)
Commercial	Space Heating	All Space Heating Base	Warehouse	Air-to-Air Heat Exchanger	3.87	(\$65.59)
Agricultural	Lighting	250-Watt Brooder Lamp	Other Farms	175-Watt Infrared Heat Lamp	0.10	(\$64.98)
Commercial	Water Heating	Base Water Heat	School	Heat Pump Water Heater	0.54	(\$64.77)
Commercial	Ventilation	All Ventilation Base	Grocery	Reduce Fan Power	0.52	(\$64.63)
Commercial	Ventilation	All Ventilation Base	Restaurant	Reduce Fan Power	0.50	(\$64.20)
Commercial	Build Envelope	Base Envelope	Grocery	Eff Build Envelope	0.21	(\$64.01)
Commercial	Ventilation	Standard Efficiency Motor	Health	High Efficiency Motors	0.11	(\$63.99)
Commercial	Refrigeration	Refrigeration Base Case	Warehouse	Head Pressure Controls	0.49	(\$63.54)
Commercial	Refrigeration	Refrigeration Base Case	Grocery	Head Pressure Controls	1.90	(\$63.42)
Commercial	Water Heating	Base Water Heat	Grocery	Heat Pump Water Heater	0.46	(\$63.25)
Commercial	Lighting	Incandescent Spots & Floods	Retail	Metal Halide	19.21	(\$63.10)
Commercial	Ventilation	Standard Efficiency Motor	Grocery	High Efficiency Motors	0.09	(\$62.19)
Commercial	Lighting	Incandescent Spots & Floods	Office	Metal Halide	16.30	(\$62.14)
Residential	Clothes Drying	Electric Dryer: Typ New	Single Family	High Spin Washer (850 rpm)	0.35	(\$61.78)
Commercial	Ventilation	Standard Efficiency Motor	Restaurant	High Efficiency Motors	0.09	(\$61.63)
Commercial	Ventilation	All Ventilation Base	Office	Reduce Fan Power	0.37	(\$61.20)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Gas furnace	5.17	(\$60.96)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Dual Fuel Heating ERH	5.17	(\$60.96)
Commercial	Ventilation	All Ventilation Base	Health	Timers for Fans	0.31	(\$60.91)
Commercial	Lighting	Standard Fluorescent Base	Lodging	HE Fluor. Lamps & Ballast. w\ Reflector	0.43	(\$60.85)
Commercial	Ventilation	All Ventilation Base	College	Reduce Fan Power	0.35	(\$60.35)
Commercial	Refrigeration	Refrigeration Base Case	Grocery	Mechanical Subcooling	3.17	(\$60.18)
Commercial	Space Heating	All Space Heating Base	School	Air-to-Air Heat Exchanger	2.31	(\$60.03)
Commercial	Lighting	Standard 8' Fluor. Base	Grocery	2-8' HEF & 1 HEB	1.36	(\$59.65)
Commercial	Space Heating	All Space Heating Base	Miscellaneous	Air-to-Air Heat Exchanger	2.23	(\$59.55)
Commercial	Ventilation	All Ventilation Base	Lodging	Reduce Fan Power	0.32	(\$59.36)
Commercial	Ventilation	All Ventilation Base	Retail	Reduce Fan Power	0.32	(\$59.36)
Commercial	Space Heating	All Space Heating Base	Grocery	Reduce Ventilation Intake	0.49	(\$59.27)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Lighting	Standard Fluorescent Base	School	HE Fluor. Lamps & Ballast. w\ Reflector	0.80	(\$59.20)
Residential	Clothes Drying	Electric Dryer: 1994 min stand	Single Family	Gas Dryer: 1994 min eff. standard	0.35	(\$59.16)
Commercial	Space Heating	All Space Heating Base	Miscellaneous	Reduce Ventilation Intake	0.49	(\$58.99)
Commercial	Space Heating	All Space Heating Base	School	Reduce Ventilation Intake	0.50	(\$58.90)
Commercial	Lighting	Standard Fluorescent Base	Health	HE Fluor. Lamps & Ballast. w\ Reflector	1.43	(\$58.82)
Commercial	Air Conditioning	All Cooling Base	Restaurant	Temperature Set-Up	0.21	(\$58.64)
Commercial	Ventilation	All Ventilation Base	Grocery	Timers for Fans	0.26	(\$58.62)
Commercial	Space Heating	All Space Heating Base	Health	Reduce Ventilation Intake	0.43	(\$58.51)
Commercial	Space Heating	All Space Heating Base	Restaurant	Reduce Ventilation Intake	0.40	(\$58.49)
Commercial	Ventilation	All Ventilation Base	Miscellaneous	Reduce Fan Power	0.30	(\$58.20)
Commercial	Refrigeration	Refrigeration Base Case	Grocery	Microprocessor Controls	2.12	(\$58.13)
Commercial	Lighting	Standard Fluorescent Base	Retail	HE Fluor. Lamps & Ballast. w\ Reflector	1.40	(\$58.12)
Commercial	Lighting	Standard 8' Fluor. Base	Retail	2-8' HEF & 1 HEB	0.64	(\$57.99)
Commercial	Ventilation	All Ventilation Base	Restaurant	Timers for Fans	0.25	(\$57.91)
Commercial	Lighting	Standard 8' Fluor. Base	Health	2-8' HEF & 1 HEB	0.65	(\$57.81)
Commercial	Lighting	Standard Fluorescent Base	Office	HE Fluor. Lamps & Ballast. w\ Reflector	1.19	(\$57.80)
Commercial	Lighting	Standard Fluorescent Base	College	HE Fluor. Lamps & Ballast. w\ Reflector	0.88	(\$57.78)
Commercial	Space Heating	All Space Heating Base	Health	Air-to-Air Heat Exchanger	1.99	(\$57.77)
Commercial	Ventilation	Standard Efficiency Motor	Office	High Efficiency Motors	0.07	(\$57.69)
Commercial	Space Heating	All Space Heating Base	Office	Reduce Ventilation Intake	0.42	(\$57.56)
Commercial	Space Heating	All Space Heating Base	Office	Air-to-Air Heat Exchanger	1.95	(\$57.45)
Commercial	Lighting	Standard Fluorescent Base	Grocery	HE Fluor. Lamps & Ballast. w\ Reflector	2.99	(\$56.93)
Residential	Lighting	40-W Fluor. w/New Ballast	Multi-family	34-W Fluor. w/Elec. Ballast	0.05	(\$56.64)
Residential	Lighting	40-W Fluor. w/New Ballast	Single Family	34-W Fluor. w/Elec. Ballast	0.05	(\$56.64)
Commercial	Ventilation	Standard Efficiency Motor	College	High Efficiency Motors	0.06	(\$56.56)
Commercial	Lighting	Standard Fluorescent Base	Restaurant	HE Fluor. Lamps & Ballast. w\ Reflector	0.80	(\$56.52)
Commercial	Lighting	Standard 8' Fluor. Base	College	2-8' HEF & 1 HEB	0.40	(\$56.50)
Commercial	Lighting	Standard 8' Fluor. Base	Restaurant	2-8' HEF & 1 HEB	0.37	(\$56.24)
Commercial	Lighting	Standard 8' Fluor. Base	Warehouse	2-8' HEF & 1 HEB	0.26	(\$56.01)
Commercial	Air Conditioning	All Cooling Base	Health	Temperature Set-up	0.18	(\$55.94)
Commercial	Lighting	4-8' HEF & 2 HEB Base	Lodging	2-8' HEF & 1 HEB & Refl.	0.52	(\$55.88)
Commercial	Lighting	Standard 8' Fluor. Base	School	2-8' HEF & 1 HEB	0.36	(\$55.75)
Commercial	Ventilation	Standard Efficiency Motor	Retail	High Efficiency Motors	0.06	(\$55.26)
Commercial	Ventilation	Standard Efficiency Motor	Lodging	High Efficiency Motors	0.06	(\$55.26)
Commercial	Ventilation	All Ventilation Base	Warehouse	Reduce Fan Power	0.25	(\$55.21)
Commercial	Lighting	All Lighting Types Base	Grocery	Occupancy Sensors	1.24	(\$55.16)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Space Heating	All Space Heating Base	Retail	Reduce Ventilation Intake	0.36	(\$55.04)
Commercial	Build Envelope	Base Envelope	Grocery	Eff Build Envelope	3.01	(\$54.98)
Industrial	Gen. Mechanical	Base Case Air Guns	All	Air-Airless Guns	0.41	(\$54.53)
Commercial	Air Conditioning	All Cooling Base	Restaurant	Reduce Ventilation Intake	0.21	(\$53.83)
Residential	Clothes Drying	Electric Dryer-1994 min std	Multi-family	Gas Dryer: 1994 min eff. standard	0.28	(\$53.75)
Commercial	Ventilation	Standard Efficiency Motor	Miscellaneous	High Efficiency Motors	0.05	(\$53.75)
Commercial	Lighting	Standard Fluorescent Base	Warehouse	HE Fluor. Lamps & Ballast. w\ Reflector	0.56	(\$53.59)
Commercial	Ventilation	All Ventilation Base	Office	Timers for Fans	0.19	(\$52.90)
Residential	Clothes Drying	Electric Dryer: Typ Existing	Multi-family	High Spin Washer (850 rpm)	0.25	(\$52.69)
Commercial	Space Heating	All Space Heating Base	Lodging	Reduce Ventilation Intake	0.31	(\$52.55)
Industrial	Process Cooling	60 Hp Base, No 1st Cost	All	Replace Dampers with Fan	1.04	(\$52.04)
Commercial	Air Conditioning	All Cooling Base	Health	Reduce Ventilation Intake	0.18	(\$51.79)
Commercial	Refrigeration	Refrigeration Base Case	Warehouse	High Efficiency Compressor	0.65	(\$51.76)
Residential	Refrigeration	Refrigerator: Primary AVG.	Single Family	Adaptive Defrost-18ft3(no CFCs)	0.54	(\$51.76)
Commercial	Space Heating	All Space Heating Base	Warehouse	Reduce Ventilation Intake	0.33	(\$51.72)
Commercial	Refrigeration	Refrigeration Base Case	Grocery	Doors/Covers on Cases	10.58	(\$51.56)
Commercial	Ventilation	All Ventilation Base	College	Timers for Fans	0.17	(\$51.47)
Commercial	Build Envelope	Base Envelope	Grocery	Eff Build Envelope	0.21	(\$51.43)
Commercial	Water Heating	Base Water Heat	Retail	Heat Pump Water Heater	0.21	(\$51.42)
Commercial	Water Heating	Base Water Heat	Office	Heat Pump Water Heater	0.21	(\$51.42)
Residential	Space Cooling	Central A/C	Multi-family	2-speed Ground Source Heat Pump (slinky)	0.23	(\$51.28)
Commercial	Space Heating	All Space Heating Base	Lodging	Air-to-Air Heat Exchanger	1.41	(\$51.25)
Commercial	Cooking	Base Cooking	Restaurant	Convection Ovens	3.07	(\$50.51)
Commercial	Ventilation	All Ventilation Base	Lodging	Timers for Fans	0.16	(\$49.82)
Commercial	Ventilation	All Ventilation Base	Retail	Timers for Fans	0.16	(\$49.82)
Commercial	Ventilation	Standard Efficiency Motor	Warehouse	High Efficiency Motors	0.04	(\$49.81)
Commercial	Air Conditioning	All Cooling Base	Office	Temperature Set-Up	0.13	(\$49.26)
Commercial	Space Heating	All Space Heating Base	College	Reduce Ventilation Intake	0.26	(\$48.95)
Industrial	Space Heating	Electric Resistance Heat	All	Electric Heat to Gas Heat	1.83	(\$48.61)
Agricultural	Stock Watering	Elect. Heated Waterer	All Farms	Efficient Waterer	0.45	(\$48.57)
Commercial	Air Conditioning	All Cooling Base	Grocery	Temperature Set-up	0.12	(\$48.46)
Agricultural	Water Heating	80-gal Elec. Water Heater	Dairy Farms	Desuperheater	6.54	(\$48.39)
Agricultural	Water Heating	80-gal elec. Water Heater	Other Farms	High eff. 80-gal Water Heater	0.28	(\$48.37)
Industrial	Compressed Air	SE Motor (No First Cost)	All	Pneumatic Motor	1.28	(\$48.25)
Commercial	Ventilation	All Ventilation Base	Miscellaneous	Timers for Fans	0.15	(\$47.90)
Commercial	Air Conditioning	All Cooling Base	Retail	Temperature Set-Up	0.12	(\$47.61)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Ventilation	All Ventilation Base	School	Reduce Fan Power	0.17	(\$47.49)
Commercial	Space Heating	All Space Heating Base	College	Air-to-Air Heat Exchanger	1.20	(\$47.31)
Commercial	Air Conditioning	All Cooling Base	Grocery	Reduce Ventilation Intake	0.12	(\$47.01)
Commercial	Refrigeration	Refrigeration Base Case	Grocery	Ambient Subcooling	1.06	(\$46.92)
Commercial	Air Conditioning	All Cooling Base	Office	Reduce Ventilation Intake	0.13	(\$46.77)
Commercial	Air Conditioning	All Cooling Base	Lodging	Temperature Set-up	0.12	(\$46.69)
Industrial	Hydraulics	200 Hp Base (No 1st Cost)	All	Downsize Motor to 60 Hp	0.50	(\$46.05)
Industrial	Space Heating	Electric Resistance Heat	All	Improved Radiant Heater	0.37	(\$46.00)
Commercial	Water Heating	Base Water Heat	Miscellaneous	Heat Pump Water Heater	0.17	(\$46.00)
Industrial	Motors	Standard Motor, All Hp	All	Downsize Motors	0.52	(\$45.91)
Industrial	Compressed Air	SE Motor (No First Cost)	All	High Efficiency Nozzles	0.13	(\$45.88)
Industrial	Gen. Mechanical	Base Case Aeration	All	Micro-Bubble Aeration	1.82	(\$45.73)
Commercial	Air Conditioning	All Cooling Base	Miscellaneous	Temperature Set-up	0.11	(\$45.71)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Efficient Heat Pump	4.77	(\$45.69)
Industrial	Air Conditioning	Base Case (125 Ton)	All	Gas Chiller (125 Ton)	0.74	(\$45.59)
Commercial	Air Conditioning	All Cooling Base	Miscellaneous	Reduce Ventilation Intake	0.11	(\$45.35)
Industrial	Drying Fans	Base Case, No 1st Cost	All	Dryer Control System	0.78	(\$44.98)
Commercial	Air Conditioning	All Cooling Base	College	Temperature Set-up	0.11	(\$44.65)
Commercial	Lighting	Standard 8' Fluor. Base	Office	2-8' HEF & 1 HEB	0.54	(\$44.22)
Residential	Clothes Drying	Electric Dryer: 1994 min std	Single Family	High Spin Washer (850 rpm)	0.20	(\$44.06)
Commercial	Air Conditioning	All Cooling Base	Retail	Reduce Ventilation Intake	0.12	(\$43.78)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Dual Fuel Heating ERH	2.52	(\$43.64)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Gas furnace	2.52	(\$43.64)
Commercial	Lighting	Standard Fluorescent Base	Grocery	HE Fluor. Lamps & Ballast. w\ Reflector	1.99	(\$43.60)
Industrial	Compressed Air	SE Motor (No First Cost)	All	Low Load Unloading	0.26	(\$43.50)
Industrial	Pumping	75 Hp Base, No 1st Cost	All	Low Flow Nozzles	0.08	(\$43.20)
Industrial	Lighting	Incandescent Lamp	All	Compact Fluorescent	0.23	(\$43.17)
Commercial	Ventilation	All Ventilation Base	Warehouse	Timers for Fans	0.12	(\$42.89)
Industrial	Ventilation	Vent. Base, No 1st Cost	All	Reduce Motor Size	0.48	(\$42.88)
Commercial	Lighting	Standard Fluorescent Base	Retail	HE Fluor. Lamps & Ballast. w\ Reflector	0.94	(\$42.68)
Industrial	Motors	40 Hp SE Motor Base	All	40 Hp HE Motor	0.12	(\$42.63)
Commercial	Build Envelope	Base Envelope	Retail	Eff. Building Envelope	2.57	(\$42.42)
Commercial	Lighting	Standard Fluorescent Base	Restaurant	HE Fluor. Lamps & Ballast. w\ Reflector	0.53	(\$42.31)
Industrial	Ventilation	Base Case	All	High Efficiency Motors	0.12	(\$41.58)
Commercial	Air Conditioning	All Cooling Base	Lodging	Reduce Ventilation Intake	0.12	(\$41.53)
Commercial	Build Envelope	Base Envelope	Lodging	Eff Build Envelope	2.83	(\$41.44)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Lighting	Standard Fluorescent Base	Office	High Eff Fluor. Lamps Only	0.79	(\$41.01)
Residential	Space Cooling	Central A/C	Single Family	2-speed Ground Source Heat Pump (horiz.)	0.29	(\$40.90)
Commercial	Air Conditioning	All Cooling Base	School	Reduce Ventilation Intake	0.09	(\$40.56)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Eff. Open Loop Ground Source Heat Pump	5.64	(\$40.32)
Commercial	Lighting	Standard Fluorescent Base	Health	High Eff Fluor. Lamps Only	0.95	(\$39.97)
Commercial	Lighting	Standard Fluorescent Base	Warehouse	High Eff Fluor. Lamps Only	0.38	(\$39.94)
Industrial	Pumping	75 Hp Pumping Base Case	All	Energy Efficient Motors	0.08	(\$39.83)
Industrial	Motors	Standard Motor - 75 Hp	All	75 Hp HE Motor	0.09	(\$39.83)
Industrial	Drying Fans	SE Drying Fan Motor	All	HE Drying Fan Motor	0.09	(\$39.83)
Commercial	Ventilation	Standard Efficiency Motor	School	High Efficiency Motors	0.03	(\$39.68)
Commercial	Air Conditioning	All Cooling Base	School	Temperature Set-up	0.09	(\$39.46)
Industrial	Compressed Air	Standard Efficiency Motor	All	High Efficiency Motors	0.08	(\$39.17)
Commercial	Lighting	Standard Fluorescent Base	School	High Eff Fluor. Lamps Only	0.53	(\$38.81)
Residential	Refrigeration	Refrigerator: Primary AVG.	Multi-family	Adaptive Defrost-18ft3(no CFCs)	0.39	(\$38.26)
Commercial	Air Conditioning	All Cooling Base	College	Reduce Ventilation Intake	0.11	(\$37.79)
Commercial	Lighting	Standard Fluorescent Base	College	High Eff Fluor. Lamps Only	0.59	(\$37.75)
Commercial	Water Heating	Base Water Heat	Warehouse	Heat Pump Water Heater	0.12	(\$36.97)
Residential	Water Heating	Electric Water Heater	Single Family	New Gas Water Heater	1.82	(\$36.95)
Industrial	Motors	Standard Motor - 150Hp	All	150 Hp HE Motor	0.08	(\$36.67)
Industrial	Motors	15 Hp SEM Base	All	15 Hp HE Motor	0.14	(\$36.21)
Industrial	Refrigeration	Refrigeration Base Case	All	High Efficiency Compressor	0.37	(\$35.91)
Commercial	Lighting	Standard 8' Fluor. Base	Miscellaneous	2-8' HEF & 1 HEB	0.27	(\$34.72)
Industrial	Lighting	Exterior Lighting	All	Photo cells	0.32	(\$34.50)
Commercial	Lighting	All Lighting Types Base	Retail	Occupancy Sensors	0.58	(\$34.43)
Residential	Lighting	Standard Incandescent Lamps	Multi-family	Compact Fluorescent Lamps	0.05	(\$34.21)
Residential	Lighting	Standard Incandescent Lamps	Single Family	Compact Fluorescent Lamps	0.05	(\$34.21)
Commercial	Refrigeration	Refrigeration Base Case	Warehouse	Head Pressure Controls	0.49	(\$34.09)
Industrial	Motors	Standard Motor, All Hp	All	Soft Start Controls	0.09	(\$34.09)
Commercial	Lighting	All Lighting Types Base	Health	Occupancy Sensors	0.57	(\$33.77)
Commercial	Lighting	Standard Fluorescent Base	Lodging	High Eff Fluor. Lamps Only	0.28	(\$33.41)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Efficient Heat Pump	4.77	(\$33.02)
Residential	Lighting	Standard Incandescent Lamps	Single Family	Halogen Incand. Lamps	0.02	(\$32.82)
Residential	Lighting	Standard Incandescent Lamps	Single Family	Halogen Incand. Lamps	0.02	(\$32.82)
Residential	Clothes Drying	Electric Dryer: 1994 min std	Multi-family	High Spin Washer (850 rpm)	0.16	(\$32.73)
Commercial	Air Conditioning	Central Chiller Base	Lodging	High Eff. Central Chiller	0.44	(\$32.40)
Industrial	Hydraulics	60 Hp Base	All	Install Efficient Motors	0.10	(\$32.36)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Air Conditioning	Central Chiller Base	Health	High Eff. Central Chiller	0.66	(\$32.28)
Industrial	Gen. Mechanical	Base Case Agitators	All	Hydrofoil Agitators	1.06	(\$31.09)
Commercial	Air Conditioning	Conventional Cooling Base	Grocery	Desiccant Dehumidifier	1.74	(\$30.74)
Industrial	Motors	5 Hp SE Motor Base	All	5 Hp HE Motor	0.16	(\$30.70)
Industrial	Lighting	8' fixture w/SE ballasts	All	8' fixtures w/HE ballasts	0.03	(\$30.02)
Commercial	Ventilation	All Ventilation Base	School	Timers for Fans	0.09	(\$30.01)
Residential	Space Heating	Gas Furnace	Single Family	Gas Absorption (GAX) Heat Pump	3.15	(\$29.93)
Residential	Space Heating	Gas Furnace	Single Family	Efficient Gas Furnace	0.95	(\$29.69)
Agricultural	Lighting	Standard Incandescent Lamps	Other Farms	Compact Fluorescent Lamps	0.07	(\$29.34)
Commercial	Air Conditioning	Central Chiller Base	Office	High Eff. Central Chiller	0.48	(\$29.19)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Efficient Heat Pump	2.32	(\$28.42)
Commercial	Refrigeration	Conventional Refrigeration	Grocery	Mechanical Refrigeration	14.82	(\$28.32)
Industrial	Material Handling	Base Case (No First Cost)	All	Pneumatic to Mechanical	1.56	(\$27.39)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Eff. Open Loop Ground Source Heat Pump	5.64	(\$26.68)
Commercial	Air Conditioning	DX Base	Health	High Efficiency DX	1.38	(\$26.19)
Commercial	Air Conditioning	DX Base	Lodging	High Efficiency DX	0.91	(\$26.16)
Residential	Water Heating	Electric Water Heater	Multi-family	New Gas Water Heater	1.40	(\$25.90)
Residential	Refrigeration	Refrigerator Prim. & Sec. Avg	Single Family	Auto-side Refrigerator-22 ft3	0.97	(\$25.77)
Industrial	Gen. Mechanical	Insulating Jackets Base	All	Install Insulating Jacket	0.52	(\$25.39)
Commercial	Air Conditioning	All Cooling Base	Warehouse	Reduce Ventilation Intake	0.06	(\$25.33)
Commercial	Air Conditioning	Central Chiller Base	Grocery	High Eff. Central Chiller	0.45	(\$25.28)
Commercial	Space Heating	All Space Heating Base	School	Tune-up/Improved Maintenance	0.50	(\$24.38)
Commercial	Air Conditioning	Central Chiller Base	Restaurant	High Eff. Central Chiller	0.78	(\$24.16)
Commercial	Air Conditioning	Central Chiller Base	Retail	High Eff. Central Chiller	0.44	(\$24.09)
Commercial	Air Conditioning	All Cooling Base	Warehouse	Temperature Set-Up	0.06	(\$23.72)
Residential	Space Cooling	Room A/C	Multi-family	Room A/C: Efficient	0.04	(\$23.48)
Commercial	Air Conditioning	Central Chiller Base	Miscellaneous	High Eff. Central Chiller	0.42	(\$22.97)
Commercial	Air Conditioning	DX Base	Office	High Efficiency DX	1.00	(\$22.88)
Commercial	Space Heating	All Space Heating Base	Miscellaneous	Tune-up/Improved Maintenance	0.49	(\$22.75)
Commercial	Space Heating	All Space Heating Base	Grocery	Tune-up/Improved Maintenance	0.49	(\$22.75)
Residential	Space Heating	Heat Pump	Multi-family	Efficient Gas Furnace	0.58	(\$22.37)
Industrial	Motors	Standard Motor - 200Hp	All	200 Hp HE Motor	0.05	(\$22.29)
Industrial	Pumping	75 Hp Base, No 1st Cost	All	Trim Pump Impellers	0.10	(\$22.13)
Residential	Space Heating	Heat Pump	Single Family	Eff. Open Loop Ground Source Heat Pump	1.02	(\$21.98)
Residential	Space Heating	Heat Pump	Multi-family	Eff. Open Loop Ground Source Heat Pump	0.58	(\$21.97)
Commercial	Lighting	All Lighting Types Base	Office	Occupancy Sensors	0.44	(\$21.78)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Industrial	Lighting	8' fixture w/SE lamp	All	8' fixture w/HE lamp	0.07	(\$21.60)
Commercial	Refrigeration	Refrigeration Base Case	Warehouse	Mechanical Subcooling	0.81	(\$21.40)
Commercial	Building Envelope	Base Envelope	Health	Eff Build Envelope	0.52	(\$19.89)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Eff. Open Loop Ground Source Heat Pump	2.74	(\$19.31)
Industrial	Space Heating	Base Case (no first cost)	All	High Efficiency Heat Pump	0.75	(\$18.62)
Industrial	Lighting	4' fixture w/SE ballast	All	4' fixtures w/HE ballasts	0.02	(\$18.47)
Commercial	Air Conditioning	DX Base	Grocery	High Efficiency DX	0.95	(\$18.47)
Industrial	Compressed Air	SE Motor (No First Cost)	All	Humidity Control	0.08	(\$18.30)
Commercial	Air Conditioning	DX Base	Restaurant	High Efficiency DX	1.62	(\$17.27)
Commercial	Air Conditioning	DX Base	Retail	High Efficiency DX	0.93	(\$17.15)
Commercial	Space Heating	All Space Heating Base	Health	Tune-up/Improved Maintenance	0.43	(\$16.58)
Commercial	Lighting	Standard 8' Fluor. Base	Lodging	2-8' HEF & 1 HEB & Refl.	0.81	(\$15.94)
Commercial	Air Conditioning	DX Base	Miscellaneous	High Efficiency DX	0.88	(\$15.91)
Commercial	Lighting	All Lighting Types Base	Restaurant	Occupancy Sensors	0.39	(\$15.78)
Commercial	Building Envelope	Base Envelope	Health	Eff Build Envelope	0.52	(\$15.64)
Commercial	Space Heating	All Space Heating Base	Office	Tune-up/Improved Maintenance	0.42	(\$15.49)
Industrial	Process Cooling	Base Case (200 HP)	All	Use Well/Ground Water	1.10	(\$14.61)
Commercial	Refrigeration	Refrigeration Base Case	Warehouse	Microprocessor Controls	0.54	(\$14.60)
Agricultural	Lighting	Mercury Vapor Lamps	All Farms	High Pressure Sodium Lamp	0.27	(\$14.59)
Industrial	Lighting	4' fixture w/SE Lamps	All	4' fixture w/HE lamp	0.03	(\$14.41)
Residential	Outdoor Lighting	Std. Outdoor Flood lamps	Multi-family	High Pressure Sodium Lamp	0.23	(\$14.18)
Residential	Outdoor Lighting	Std. Outdoor Flood lamps	Single Family	High Pressure Sodium Lamp	0.23	(\$14.18)
Commercial	Building Envelope	Base Envelope	Warehouse	Eff. Building Envelope	1.31	(\$13.11)
Industrial	Compressed Air	SE Motor (No First Cost)	All	Lead-lag Controls	0.08	(\$12.70)
Commercial	Space Heating	All Space Heating Base	Restaurant	Tune-up/Improved Maintenance	0.40	(\$12.57)
Industrial	Space Heating	Base Case (no first cost)	All	Air-to-Air Heat Exchanger	0.22	(\$12.34)
Commercial	Lighting	Standard Fluorescent Base	Miscellaneous	HE Fluor. Lamps & Ballast. w\ Reflector	0.59	(\$9.24)
Industrial	Refrigeration	Refrigeration Base Case	All	Gas-Fired Mechanical Refrigerator	3.73	(\$8.43)
Commercial	Building Envelope	Base Envelope	Office	Eff. Building Envelope	1.35	(\$8.06)
Industrial	Air Conditioning	Base Case (200 Ton)	All	High Efficiency (200 Ton)	0.25	(\$7.66)
Residential	Space Cooling	Central A/C	Multi-family	2-speed Ground Source Heat Pump (well)	0.23	(\$6.88)
Commercial	Air Conditioning	All Cooling Base	Restaurant	Economizer	1.69	(\$6.27)
Commercial	Building Envelope	Base Envelope	Health	Eff Build Envelope	1.07	(\$5.82)
Residential	Space Cooling	Central A/C	Single Family	2-speed Ground Source Heat Pump (vertical)	0.29	(\$5.79)
Commercial	Space Heating	All Space Heating Base	Retail	Tune-up/Improved Maintenance	0.36	(\$4.95)

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Ventilation	All Ventilation Base	Health	Adjustable Speed Drive	1.04	(\$3.94)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Eff. Closed Loop Ground Source Heat Pump	5.27	(\$3.65)
Commercial	Air Conditioning	All Cooling Base	Miscellaneous	Economizer	0.90	(\$2.97)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Efficient Heat Pump	2.32	(\$2.36)
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	2-speed Ground Source Heat Pump (slinky)	5.60	(\$2.25)
Residential	Space Heating	Gas Furnace	Single Family	Gas Absorption (GAX) H. Pump	3.15	(\$0.26)
Industrial	Lighting	4&8' L&B, no first costs	All	Reflectors & Delamping	0.11	(\$0.20)
Industrial	Lighting	Metal Halide Base	All	High Pressure Sodium	0.16	\$0.78
Commercial	Space Heating	All Space Heating Base [C	Warehouse	Tune-up/Improved Maintenance	0.33	\$1.00
Commercial	Building Envelope	Base Envelope	Retail	Eff. Building Envelope	2.86	\$1.06
Commercial	Air Conditioning	Central Chiller Base	College	High Eff. Central Chiller	0.39	\$1.66
Commercial	Lighting	All Lighting Types Base	College	Occupancy Sensors	0.30	\$1.79
Industrial	Air Conditioning	Base Case (125 Ton)	All	High Efficiency (125 Ton)	0.25	\$3.31
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	2-speed Ground Source Heat Pump (well)	5.60	\$3.65
Residential	Space Heating	Gas Furnace	Multi-family	Gas Absrp (GAX) Heat Pump	1.93	\$4.32
Industrial	Motors	Standard Motor, All Hp	All	Replace Babbit Bearings	0.52	\$4.55
Commercial	Building Envelope	Base Envelope	Lodging	Eff Build Envelope	2.83	\$5.63
Commercial	Space Heating	All Space Heating Base [C	Lodging	Tune-up/Improved Maintenance	0.31	\$5.95
Agricultural	Lighting	Std. Incandescent Lamps	Dairy Farms	Compact Fluorescent Fixture	0.1272	\$6.13
Commercial	Building Envelope	Base Envelope	Office	Eff Build Envelope	0.33	\$6.22
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Eff. Open Loop Ground Source Heat Pump	2.74	\$8.77
Industrial	Gen. Mechanical	ASD Base	All	ASD on Paper Machine	1.11	\$8.96
Commercial	Space Heating	All Space Heating Base	Miscellaneous	Air Source Heat Pump	3.98	\$9.24
Commercial	Ventilation	All Ventilation Base	Grocery	Adjustable Speed Drive	0.87	\$9.32
Residential	Refrigeration	Refrig: non-autodefrost AVG.	Single Family	Golden Carrot Refrig.-22ft3	0.13	\$10.44
Industrial	Compressed Air	SE Motor (No First Cost)	All	Low Pressure Blower	0.38	\$10.66
Industrial	Air Conditioning	C&P Base, No Inst. Cost	All	Improved Control System	0.02	\$11.10
Commercial	Air Conditioning	DX Base	College	High Efficiency DX	0.82	\$11.81
Industrial	Process Cooling	Base Case (60 HP)	All	Adjustable Speed Drives	1.61	\$11.81
Commercial	Space Heating	All Space Heating Base	Grocery	Air Source Heat Pump	3.98	\$12.25
Commercial	Ventilation	All Ventilation Base	Restaurant	Adjustable Speed Drive	0.83	\$13.46
Industrial	Compressed Air	SE Motor (No First Cost)	All	Rework Existing Pipes	0.13	\$14.04
Commercial	Air Conditioning	Central Chiller Base	School	High Eff. Central Chiller	0.33	\$15.65
Residential	Space Heating	Gas Furnace	Single Family	Gas Engine Heat Pump	3.88	\$16.42
Residential	Refrigeration	Refrig: non-autodefrost AVG.	Single Family	Adaptive Defrost-18ft3 (no CFCs)	0.31	\$16.49
Residential	Space Heating	Gas Furnace	Multi-family	Efficient Gas Furnace	0.58	\$17.89

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Lighting	All Lighting Types Base	School	Occupancy Sensors	0.24	\$18.60
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	Eff. Closed Loop Ground Source Heat Pump	5.27	\$19.30
Commercial	Space Heating	All Space Heating Base [C	College	Tune-up/Improved Maintenance	0.26	\$19.58
Industrial	Ventilation	Vent. Base, No 1st Cost	All	Adjustable Speed Drives	1.24	\$21.23
Commercial	Space Heating	All Space Heating Base	Office	Air Source Heat Pump	3.47	\$21.34
Commercial	Lighting	Standard Fluorescent Base	Miscellaneous	High Eff Fluor. Lamps Only	0.40	\$25.99
Industrial	Lighting	4&8' L&B, with first cost	All	HPS (Fluorescent Base)	0.08	\$26.63
Commercial	Building Envelope	Base Envelope	School	Eff Build Envelope	1.21	\$26.75
Commercial	Air Conditioning	DX Base	School	High Efficiency DX	0.70	\$27.53
Agricultural	Process Related	Direct-Exp Refrigeration	Dairy Farms	Well Water Pre-Cooler	2.28	\$28.52
Commercial	Refrigeration	Refrigeration Base Case	Warehouse	Ambient Subcooling	0.27	\$30.65
Industrial	Air Conditioning	Base Case (50 Ton)	All	High Efficiency (50 Ton)	0.17	\$30.72
Commercial	Space Heating	All Space Heating Base	Lodging	Air Source Heat Pump	2.52	\$31.43
Residential	Water Heating	Electric Water Heater	Single Family	Heat Pump Water Heater	1.62	\$34.07
Industrial	Material Handling	Base Case (No First Cost)	All	Energy Efficient Motors	0.08	\$35.26
Commercial	Air Conditioning	Central Chiller Base	Warehouse	High Eff. Central Chiller	0.24	\$35.46
Commercial	Space Heating	All Space Heating Base	Miscellaneous	Ground Source Heat Pump	6.31	\$35.87
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Eff. Closed Loop Ground Source Heat Pump	2.56	\$36.96
Residential	Clothes Drying	Gas Dryer: Typical New	Single Family	High Spin Washer (850 rpm)	0.06	\$37.40
Industrial	Process Cooling	Base Case (200 HP)	All	Well/Ground Water w/Condenser	1.50	\$39.31
Commercial	Space Heating	All Space Heating Base	Grocery	Ground Source Heat Pump	6.31	\$39.42
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	2-speed Ground Source Heat Pump (horiz.)	5.60	\$40.18
Commercial	Air Conditioning	All Cooling Base	Health	Economizer	0.71	\$40.38
Commercial	Air Conditioning	All Cooling Base	Lodging	Economizer	0.46	\$41.78
Commercial	Lighting	Mercury Vapor Base	Grocery	High Pressure Sodium	1.89	\$42.45
Commercial	Ventilation	All Ventilation Base	Office	Adjustable Speed Drive	0.62	\$42.45
Commercial	Space Heating	All Space Heating Base	Retail	Air Source Heat Pump	2.93	\$42.99
Industrial	Compressed Air	SE Motor (No First Cost)	All	Fast Control Compressors	0.13	\$43.97
Commercial	Building Envelope	Base Envelope	School	Eff Build Envelope	0.37	\$45.80
Commercial	Building Envelope	Base Envelope	Miscellaneous	Eff Build Envelope	1.85	\$45.88
Commercial	Space Heating	All Space Heating Base	School	Air Source Heat Pump	4.12	\$46.00
Residential	Space Heating	Elect. Furnace w/Std. Therm	Single Family	2-speed Ground Source Heat Pump (vertical)	5.60	\$47.41
Commercial	Air Conditioning	All Cooling Base	Office	Economizer	0.51	\$49.33
Commercial	Air Conditioning	DX Base	Warehouse	High Efficiency DX	0.49	\$49.87
Commercial	Ventilation	All Ventilation Base	College	Adjustable Speed Drive	0.58	\$50.74

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Lighting	All Lighting Types Base	Warehouse	Occupancy Sensors	0.18	\$50.76
Industrial	Refrigeration	Refrig. Base, no 1st cost	All	Install More Condensers	0.19	\$51.30
Commercial	Space Heating	All Space Heating Base	Office	Ground Source Heat Pump	5.50	\$51.89
Commercial	Air Conditioning	All Cooling Base	Grocery	Economizer	0.50	\$53.42
Residential	Space Heating	Heat Pump	Single Family	Eff. Open Loop Ground Source Heat Pump	1.02	\$53.53
Commercial	Space Heating	All Space Heating Base	Health	Air Source Heat Pump	3.54	\$53.61
Residential	Space Heating	Gas Furnace	Single Family	Gas Engine Heat Pump	3.88	\$55.49
Commercial	Building Envelope	Base Envelope	Warehouse	Eff. Building Envelope	1.31	\$60.20
Commercial	Ventilation	All Ventilation Base	Retail	Adjustable Speed Drive	0.54	\$60.30
Commercial	Ventilation	All Ventilation Base	Lodging	Adjustable Speed Drive	0.54	\$60.30
Commercial	Air Conditioning	All Cooling Base	Retail	Economizer	0.48	\$61.57
Commercial	Lighting	All Lighting Types Base	Lodging	Occupancy Sensors	0.17	\$62.24
Commercial	Lighting	All Lighting Types Base	Miscellaneous	Occupancy Sensors	0.16	\$63.37
Residential	Space Heating	Gas Furnace	Multi-family	Gas Absorption (GAX) Heat Pump	1.93	\$64.82
Industrial	Material Handling	Base Case (No First Cost)	All	High Efficiency Blowers	0.78	\$66.33
Industrial	Lighting	Incandescent & Fluorescent	All	Lighting Level Control	0.05	\$67.96
Commercial	Space Heating	All Space Heating Base	Lodging	Ground Source Heat Pump	3.99	\$69.17
Commercial	Air Conditioning	All Cooling Base	Health	Improved Maintenance	0.71	\$69.88
Commercial	Lighting	Mercury Vapor Base	Restaurant	High Pressure Sodium	0.50	\$70.04
Residential	Water Heating	Electric Water Heater	Multi-family	Heat Pump Water Heater	1.25	\$70.16
Industrial	Motors	Standard Motor, All Hp	All	Solid St. Motor Generator	0.36	\$71.16
Commercial	Ventilation	All Ventilation Base	Miscellaneous	Adjustable Speed Drive	0.50	\$71.45
Commercial	Building Envelope	Base Envelope	Miscellaneous	Eff Build Envelope	0.27	\$73.03
Commercial	Ventilation	All Ventilation Base	Restaurant	Separate Make-up Air for	0.33	\$73.28
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	2-speed Ground Source Heat Pump (slinky)	2.73	\$74.87
Residential	Clothes Drying	Gas Dryer: Typical New	Multi-family	High Spin Washer (850 rpm)	0.05	\$74.91
Commercial	Building Envelope	Base Envelope	College	Eff Build Envelope	0.63	\$75.17
Residential	Space Heating	Heat Pump	Single Family	Efficient Heat Pump	0.37	\$75.62
Commercial	Building Envelope	Base Envelope	School	Eff Build Envelope	1.21	\$75.94
Residential	Space Heating	Gas Furnace	Multi-family	Gas Engine Heat Pump	2.38	\$76.00
Commercial	Space Heating	All Space Heating Base	School	Ground Source Heat Pump	6.53	\$78.35
Commercial	Lighting	Mercury Vapor Base	Retail	High Pressure Sodium	0.88	\$78.57
Commercial	Space Heating	All Space Heating Base	Retail	Ground Source Heat Pump	4.64	\$79.95
Commercial	Space Heating	All Space Heating Base	Warehouse	Air Source Heat Pump	2.69	\$80.23
Commercial	Air Conditioning	All Cooling Base	Office	Improved Maintenance	0.51	\$80.37
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	Eff. Close Loop Ground Source Heat Pump	2.56	\$84.19

Sector	End Use	Base Technology	Segment	End Use Efficiency Option	CO2 Savings (tons)	Cost (\$/ton)
Commercial	Lighting	Mercury Vapor Base	Health	High Pressure Sodium	0.90	\$85.23
Residential	Space Heating	Elect. Furnace w/Std. Therm	Multi-family	2-speed Ground Source Heat Pump (well)	2.73	\$86.20
Industrial	Air Conditioning	C&P Base, No Inst. Cost	All	Economizer	0.17	\$87.10
Commercial	Space Heating	All Space Heating Base	Health	Ground Source Heat Pump	5.61	\$89.32
Commercial	Air Conditioning	All Cooling Base	Lodging	Improved Maintenance	0.46	\$89.67
Industrial	Material Handling	Base Case (No First Cost)	All	ASDs on Conveyors	0.39	\$90.06
Commercial	Air Conditioning	Room AC Base	Health	High Efficiency Room AC	0.46	\$90.66
Commercial	Air Conditioning	Room AC Base	Lodging	High Efficiency Room AC	0.30	\$90.79
Industrial	Motors	Standard Motor, All Hp	All	Adjustable Speed Drives	0.39	\$91.00
Commercial	Lighting	Mercury Vapor Base	Office	High Pressure Sodium	0.75	\$94.79
Industrial	Refrigeration	Refrigeration Base Case	All	High Efficiency Model	0.56	\$98.77

Appendix B

Electric Generation Cost Analysis

The costs and benefits addressed for generation are shown in Table B.1. These costs were levelized over the measure's lifetime using a 5.5% discount rate to yield the annual cost. The analysis does not discount for inflationary impacts and presents all levelized costs in 1993 constant dollars. The fixed costs for both generation and DSM measures including capital, installation, capacity value, and transmission and distribution costs were levelized using a fixed charge rate based on the lifetime of the option. This calculation is:

$$\text{Annual Fixed Cost (\$/yr)} = \text{Initial Fixed Cost (\$)} * \text{Fixed Charge Rate (\%)}$$

The fixed charge rate of 10.5 % was calculated using the Electric Power Research Institute's CCLN program. This program determines the fixed charge rate for levelizing the fixed costs of new power generation facilities based on typical utility debt amortization practices, the assumed discount rate, lifetime of the measure, and various other factors specific to the industry.

Table B.1 Generation Analysis Parameters

Parameter	Cost	Levelization Parameter
Capital & Installation (\$/unit)	See Table B.2	Capital Carrying Rate = 10.5%
O&M (\$/unit-yr)	See Table B.2	Escalation Rate = 0.00%
Fuel (\$/mmBtu):		Escalation Rates =
Coal	\$1.04	3.00%
Natural Gas	\$2.44	4.50%
Biomass (wood)	\$1.0 - \$2.56	0.00%
Wind	\$0	0.00%
Solar	\$0	0.00%
SO ₂ (\$/ton)	\$100	Escalation Rate = 0.00%
Transmission and Distribution (\$/kW)	\$100	Escalation = 0.00%
Capacity Value (\$/kW)	\$56.5	Value of Levelized 40 MW CT

The variable cost of operation and maintenance (O&M), fuel, and emissions are presented on an annual basis and are usually related to the operational duration or load. These costs were levelized using the following method:

$$\text{Annual Levelized Cost (\$/yr-unit)} = \text{Initial Annual Cost (\$/yr-unit)} * \text{Levelization Factor}$$

The calculation of the levelization factor follows the procedure outlined in the Electric Power Research Institute (EPRI) Technical Assessment Guide, Volume II, 1994.

$$\text{Levelization Factor} = K * (1 - K^n) / [An * (1 - K)]$$

$$\begin{aligned} \text{An (present value factor)} &= [(1 + \text{rdrate})^n - 1] / [\text{rdrate} * (1 + \text{rdrate})^n] \\ \text{K (escalation factor)} &= (1 + \text{escrate}) / (1 + \text{rdrate}) \\ \text{escrate (\%)} &= [(1 + \text{escrate}) * (1 + \text{inflation rate})] - 1 \end{aligned}$$

where: rdrate = real discount rate.

escrate = real escalation rate (@ inflation = 0), or actual escalation rate (@ inflation > 0).

inflation = annual inflation rate, when = 0 then analysis is in real constant dollars, when > 0 then analysis is in terms of current dollars.

n = lifetime of the option or unit in years.

The annual fuel costs were levelized using escalation rates specific to each end use and utility sectors as projected by the U.S. DOE/EIA, *State Energy Price and Expenditure Report 1995*, (DOE/EIA-0376(95), August 1998). Sulfur Dioxide emissions were monetized at \$100 per ton to reflect current values in the trading market at the time of the analysis in early 1998. Current values of sulfur dioxide emissions are closer to \$200 per ton in March, 1999 which would increase the cost savings from generation measures. The control of NO_x and particulates can also be substantial but are not included in this evaluation.

Determining Electric Energy and Capacity Costs

The delivery of energy to the end user usually involves two types of cost. The first is the actual cost of the energy and the second is the cost of the infrastructure or available capacity needed to meet the peak energy requirement (demand).

The contribution of electric capacity made to the electric system resources from either DSM savings or the installation of a new generation is measured relative to the typical new peak load generation unit. This analysis used the capacity value 56.5 \$/kW determined for a 40 MW combustion turbine in the cost analysis. This was chosen because it represented the smallest likely addition to the electric utility system. It however compares very closely to other peak load options of 83 and 120 MW units both valued at 56.4 \$/kW. The capacity value for all of the generation options considered in this analysis are shown in Table B.2.

A combustion turbine is used for meeting peak load requirements because it is readily available whenever the peak demand occurs. The capacity savings or availability from DSM and other generation options does not always coincide with time of peak load requirement. Therefore, this amount of capacity must be adjusted to reflect its availability. This availability is represented by a Capacity Contribution Index (CCI). For generation units this is percent of time that the unit is not under going maintenance or down time. The ratio of the option CCI to the combustion CCI can then be used to put the available capacity in terms of equivalent combustion turbine capacity (CT equiv). This calculation is given as:

$$\text{Cap Savings-CT equiv. (kW)} = \text{Option Capacity (kW/yr)} * \text{CCI option} / \text{CCIct}$$

The value of available capacity can then be calculated by:

$$\text{Capacity Value (\$)} = \text{Cap Savings-CT EQUIV. (kW)} * \text{CT Capacity Value (\$/kW)}$$

Table B.2 Evaluated Generation Options with Cost and Operational Parameters

Generation Technology	Load Type	Nom. Cap 90 F MW	Typical Capacity Factor	Years to Constr	Unit Life	Installed Capital Cost (\$/kW)	Fixed O&M (\$/kW-yr)	Variable O&M (\$/kW)	Transmission Cost (\$/kW)	Distribution Cost (\$/kW)	Heat Rate (BTU/kWh)	Fuel	Emission Factors (lbs./MMBtu)				
													GHG	SO2	NOx	Hg	PART
Coal Fluidized Bed Combustion	Base	400	80	4	30	1,346	22.91	0.00262	100	100	11,308	Coal	235	0.170	0.150	4.7E-05	0.200
Integrated Gasification Combined Cycle	Base	500	80	3	30	1,456	44.50	0.0041	100	100	9,260	Coal	220	0.045	0.101	4.7E-05	0.000
Integrated Gasification Fuel Cell	Base	400	80	3	30	1,847	54.10	0.0073	100	100	7,020	Coal	218	0.003	0.000	4.7E-05	0.030
Atmospheric Fluidized Bed Combustion	Base	200	80	3	30	1,545	42.20	0.0032	100	100	10,444	Coal	232	0.088	0.100	4.7E-05	0.015
154 MW Combined Cycle - single unit	Intermediate	154	50	2	30	596	26.62	0.00041	100	100	8,827	Nat Gas	99	0.000	0.024	0	0.003
215 MW Combined Cycle - single unit	Intermediate	215	50	3	30	543	20.42	0.00032	100	100	8,398	Nat Gas	98	0.000	0.011	0	0.008
215 MW Combined Cycle - multiple units	Intermediate	215	50	3	30	581	20.42	0.00032	100	100	8,398	Nat Gas	98	0.000	0.011	0	0.008
215 MW Combined Cycle - multiple units	Intermediate	215	50	3	30	496	14.26	0.00032	100	100	8,398	Nat Gas	98	0.000	0.011	0	0.008
Molten Carbonate Fuel Cell	Intermediate	2	50	0.3	30	1,760	13.20	0.002	100	100	7,580	Nat Gas	128	0.004	0.003	0	0.000
75 MW Combustion Turbine - single unit	Peaking	75	50	2	30	386	5.68	0.00118	100	100	12,422	Nat Gas	99	0.000	0.024	0	0.003
83 MW Combustion Turbine - single unit	Peaking	83	50	2	30	388	6.80	0.0069	100	100	12,038	Nat Gas	142	0.000	0.090	0	0.000
154 MW Combustion Turbine - single unit	Peaking	154	50	2	30	329	3.84	0.00091	100	100	12,649	Nat Gas	98	0.000	0.020	0	0.008
154 MW Combustion Turbine - multiple units	Peaking	154	50	2	30	345	3.84	0.00091	100	100	12,649	Nat Gas	98	0.000	0.020	0	0.008
154 MW Combustion Turbine - multiple units	Peaking	154	50	2	30	276	2.36	0.00091	100	100	12,649	Nat Gas	98	0.000	0.020	0	0.008
Atmospheric Fluidized Bed Combustion - Biomass	Base	30	80	2	30	2,001	84.70	0.0021	100	100	16,980	Biomass	0	0.008	0.220	0	---
Spreader Stoker - Biomass (7.2)	Base	7.2	80	2	30	3,409	203.00	0.00673	100	100	13,500	Biomass	0	0.008	0.127	0	---
Spreader Stoker - Biomass (57)	Base	57	80	2	30	1,640	46.75	0.00485	100	100	13,500	Biomass	0	0.008	0.127	0	---
Whole Tree - Biomass	Base	100	80	2	30	1,238	43.50	0.0017	100	100	10,654	Biomass	0	0.008	0.127	0	---
Integrated Gasification Combined Cycle - Biomass	Base	100	80	2	30	2,400	55.36	0.0023	100	100	9,500	Biomass	0	0.008	0.127	0	---
Wind Turbine	Intermediate	10	20	1	30	1,049	0.00	0.0092	100	100	3,413	Wind	0	0.000	0.000	0	---
Flat Plate Photovoltaic	Intermediate	5	20	1	30	4,788	10.20	0	100	100	3,413	Solar	0	0.000	0.000	0	---
Flat Plate Photovoltaic	Intermediate	0.5	20	1	30	6,588	14.35	0	100	100	3,413	Solar	0	0.000	0.000	0	---
Flat Plate Photovoltaic - dispersed connection	Intermediate	5	20	1	30	4,788	10.20	0	0	0	3,413	Solar	0	0.000	0.000	0	---
Fixed Flat Plate Photovoltaic - dispersed connection	Intermediate	0.5	20	1	30	6,588	14.35	0	0	0	3,413	Solar	0	0.000	0.000	0	---

Table B.3 The Residential Incremental Cost of Reduced Emission Electricity

WISCONSIN			Average Electricity Characteristics				Average Consumption		
			Price (\$/kWh) =	\$0.069	Monthly =	713	lbs. CO2/kWh =	2.23	Yearly =
Consumer Electric Cost									
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase
Coal Fluidized Bed Combustion	400	80	(0.000280)	-25%	(\$0.0278)	No Reduction	(\$20)	(\$238)	-40%
Integrated Gasification Combined Cycle	500	80	0.000041	4%	(\$0.0235)	(\$573)	(\$17)	(\$201)	-34%
Integrated Gasification Fuel Cell	400	80	0.000310	28%	(\$0.0146)	(\$47)	(\$10)	(\$125)	-21%
Atmospheric Fluidized Bed Combustion	200	80	(0.000157)	-14%	(\$0.0217)	No Reduction	(\$15)	(\$186)	-32%
154 MW Combined Cycle (CC) - stand alone	154	50	0.000655	59%	(\$0.0166)	(\$25)	(\$12)	(\$142)	-24%
215 MW CC - stand alone	215	50	0.000680	61%	(\$0.0217)	(\$32)	(\$15)	(\$186)	-32%
215 MW CC - unit 1	215	50	0.000680	61%	(\$0.0206)	(\$30)	(\$15)	(\$177)	-30%
215 MW CC - unit n	215	50	0.000680	61%	(\$0.0246)	(\$36)	(\$18)	(\$211)	-36%
Molten Carbonate Fuel Cell	2	50	0.000606	54%	\$0.0089	\$15	\$6	\$77	13%
75 MW Combustion Turbine (CT) - stand alone	75	50	0.000468	42%	(\$0.0120)	(\$26)	(\$9)	(\$103)	-17%
83 MW CT - stand alone	83	50	0.000218	20%	(\$0.0066)	(\$30)	(\$5)	(\$56)	-10%
154 MW CT - stand alone	154	50	0.000460	41%	(\$0.0134)	(\$29)	(\$10)	(\$115)	-20%
154 MW CT - unit 1	154	50	0.000460	41%	(\$0.0130)	(\$28)	(\$9)	(\$111)	-19%
154 MW CT - unit n	154	50	0.000460	41%	(\$0.0153)	(\$33)	(\$11)	(\$131)	-22%
Atmospheric Fluidized Bed Biomass	30	80	0.001115	100%	\$0.0278	\$25	\$20	\$238	40%
Spreader Stoker Biomass (7.2)	7	80	0.001115	100%	\$0.0425	\$38	\$30	\$364	62%
Spreader Stoker Biomass (57)	57	80	0.001115	100%	\$0.0080	\$7	\$6	\$68	12%
Whole Tree Biomass	100	80	0.001115	100%	(\$0.0118)	(\$11)	(\$8)	(\$101)	-17%
Integrated Gasification Combined Cycle Biomass	100	80	0.001115	100%	\$0.0078	\$7	\$6	\$67	11%
Wind Turbine	10	20	0.001115	100%	\$0.0211	\$19	\$15	\$181	31%
Fixed Flat Plate Photovoltaic (5)	5	20	0.001115	100%	\$0.2787	\$250	\$199	\$2,386	405%
Fixed Flat Plate Photovoltaic (0.5)	0.5	20	0.001115	100%	\$0.4074	\$365	\$291	\$3,487	592%
Fixed Flat Plate Photovoltaic (5), dispersed connection	5	20	0.001115	100%	\$0.2562	\$230	\$183	\$2,193	372%
Fixed Flat Plate Photovoltaic (0.5), dispersed connection	0.5	20	0.001115	100%	\$0.3816	\$342	\$272	\$3,266	555%

Table B.4 The Residential Incremental Cost of Reduced Emission Electricity

MINNESOTA			Average Electricity Characteristics				Average Consumption		
			Price (\$/kWh) =	\$0.071	Monthly =	757	lbs. CO2/kWh =	2.32	Yearly =
Consumer Electric Cost									
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase
Coal Fluidized Bed Combustion	400	80	(0.000235)	-20%	(\$0.0303)	No Reduction	(\$23)	(\$275)	-42%
Integrated Gasification Combined Cycle	500	80	0.000086	7%	(\$0.0260)	(\$302)	(\$20)	(\$237)	-37%
Integrated Gasification Fuel Cell	400	80	0.000355	31%	(\$0.0171)	(\$48)	(\$13)	(\$155)	-24%
Atmospheric Fluidized Bed Combustion	200	80	(0.000112)	-10%	(\$0.0242)	No Reduction	(\$18)	(\$220)	-34%
154 MW Combined Cycle (CC) - stand alone	154	50	0.000700	60%	(\$0.0191)	(\$27)	(\$14)	(\$174)	-27%
215 MW CC - stand alone	215	50	0.000725	63%	(\$0.0242)	(\$33)	(\$18)	(\$220)	-34%
215 MW CC - unit 1	215	50	0.000725	63%	(\$0.0231)	(\$32)	(\$18)	(\$210)	-32%
215 MW CC - unit n	215	50	0.000725	63%	(\$0.0271)	(\$37)	(\$21)	(\$247)	-38%
Molten Carbonate Fuel Cell	2	50	0.000651	56%	\$0.0064	\$10	\$5	\$58	9%
75 MW Combustion Turbine (CT) - stand alone	75	50	0.000513	44%	(\$0.0145)	(\$28)	(\$11)	(\$132)	-20%
83 MW CT - stand alone	83	50	0.000263	23%	(\$0.0091)	(\$35)	(\$7)	(\$82)	-13%
154 MW CT - stand alone	154	50	0.000505	44%	(\$0.0159)	(\$31)	(\$12)	(\$145)	-22%
154 MW CT - unit 1	154	50	0.000505	44%	(\$0.0155)	(\$31)	(\$12)	(\$141)	-22%
154 MW CT - unit n	154	50	0.000505	44%	(\$0.0178)	(\$35)	(\$13)	(\$162)	-25%
Atmospheric Fluidized Bed Biomass	30	80	0.001160	100%	\$0.0253	\$22	\$19	\$230	35%
Spreader Stoker Biomass (7.2)	7	80	0.001160	100%	\$0.0400	\$35	\$30	\$364	56%
Spreader Stoker Biomass (57)	57	80	0.001160	100%	\$0.0055	\$5	\$4	\$50	8%
Whole Tree Biomass	100	80	0.001160	100%	(\$0.0143)	(\$12)	(\$11)	(\$130)	-20%
Integrated Gasification Combined Cycle Biomass	100	80	0.001160	100%	\$0.0053	\$5	\$4	\$48	7%
Wind Turbine	10	20	0.001160	100%	\$0.0186	\$16	\$14	\$169	26%
Fixed Flat Plate Photovoltaic (5)	5	20	0.001160	100%	\$0.2762	\$238	\$209	\$2,510	387%
Fixed Flat Plate Photovoltaic (0.5)	0.5	20	0.001160	100%	\$0.4049	\$349	\$307	\$3,679	568%
Fixed Flat Plate Photovoltaic (5), dispersed connection	5	20	0.001160	100%	\$0.2537	\$219	\$192	\$2,305	356%
Fixed Flat Plate Photovoltaic (0.5), dispersed connection	0.5	20	0.001160	100%	\$0.3791	\$327	\$287	\$3,444	532%

Table B.5 The Residential Incremental Cost of Reduced Emission Electricity

ILLINOIS			Average Electricity Consumption				Average Consumption			
			Price (\$/kWh) =	\$0.103	Monthly =	679	lbs. CO2/kWh =	2.17	Yearly =	8,153
Consumer Electric Cost										
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase	
Coal Fluidized Bed Combustion	400	80	(0.000310)	-29%	(\$0.0620)	No Reduction	(\$42)	(\$505)	-60%	
Integrated Gasification Combined Cycle	500	80	0.000011	1%	(\$0.0577)	(\$5,207)	(\$39)	(\$471)	-56%	
Integrated Gasification Fuel Cell	400	80	0.000280	26%	(\$0.0488)	(\$174)	(\$33)	(\$398)	-47%	
Atmospheric Fluidized Bed Combustion	200	80	(0.000187)	-17%	(\$0.0559)	No Reduction	(\$38)	(\$456)	-54%	
154 MW Combined Cycle (CC) - stand alone	154	50	0.000625	58%	(\$0.0508)	(\$81)	(\$35)	(\$414)	-49%	
215 MW CC - stand alone	215	50	0.000650	60%	(\$0.0559)	(\$86)	(\$38)	(\$456)	-54%	
215 MW CC - unit 1	215	50	0.000650	60%	(\$0.0548)	(\$84)	(\$37)	(\$447)	-53%	
215 MW CC - unit n	215	50	0.000650	60%	(\$0.0588)	(\$90)	(\$40)	(\$480)	-57%	
Molten Carbonate Fuel Cell	2	50	0.000576	53%	(\$0.0253)	(\$44)	(\$17)	(\$206)	-25%	
75 MW Combustion Turbine (CT) - stand alone	75	50	0.000438	40%	(\$0.0462)	(\$105)	(\$31)	(\$377)	-45%	
83 MW CT - stand alone	83	50	0.000188	17%	(\$0.0408)	(\$217)	(\$28)	(\$332)	-40%	
154 MW CT - stand alone	154	50	0.000430	40%	(\$0.0476)	(\$111)	(\$32)	(\$388)	-46%	
154 MW CT - unit 1	154	50	0.000430	40%	(\$0.0472)	(\$110)	(\$32)	(\$385)	-46%	
154 MW CT - unit n	154	50	0.000430	40%	(\$0.0495)	(\$115)	(\$34)	(\$404)	-48%	
Atmospheric Fluidized Bed Biomass	30	80	0.001085	100%	(\$0.0064)	(\$6)	(\$4)	(\$52)	-6%	
Spreader Stoker Biomass (7.2)	7	80	0.001085	100%	\$0.0083	\$8	\$6	\$68	8%	
Spreader Stoker Biomass (57)	57	80	0.001085	100%	(\$0.0262)	(\$24)	(\$18)	(\$214)	-25%	
Whole Tree Biomass	100	80	0.001085	100%	(\$0.0460)	(\$42)	(\$31)	(\$375)	-45%	
Integrated Gasification Combined Cycle Biomass	100	80	0.001085	100%	(\$0.0264)	(\$24)	(\$18)	(\$215)	-26%	
Wind Turbine	10	20	0.001085	100%	(\$0.0131)	(\$12)	(\$9)	(\$107)	-13%	
Fixed Flat Plate Photovoltaic (5)	5	20	0.001085	100%	\$0.2445	\$225	\$166	\$1,994	237%	
Fixed Flat Plate Photovoltaic (0.5)	0.5	20	0.001085	100%	\$0.3732	\$344	\$254	\$3,043	362%	
Fixed Flat Plate Photovoltaic (5), dispersed connection	5	20	0.001085	100%	\$0.2220	\$205	\$151	\$1,810	216%	
Fixed Flat Plate Photovoltaic (0.5), dispersed connection	0.5	20	0.001085	100%	\$0.3474	\$320	\$236	\$2,832	337%	

Table B.6 The Residential Incremental Cost of Reduced Emission Electricity

IOWA			Average Electricity Consumption				Average Consumption			
			Price (\$/kWh) =	\$0.082	Monthly =	808	lbs. CO2/kWh =	2.29	Yearly =	9,695
Consumer Electric Cost										
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase	
Coal Fluidized Bed Combustion	400	80	(0.000250)	-22%	(\$0.0406)	No Reduction	(\$33)	(\$393)	-50%	
Integrated Gasification Combined Cycle	500	80	0.000071	6%	(\$0.0363)	(\$511)	(\$29)	(\$352)	-45%	
Integrated Gasification Fuel Cell	400	80	0.000340	30%	(\$0.0274)	(\$81)	(\$22)	(\$266)	-34%	
Atmospheric Fluidized Bed Combustion	200	80	(0.000127)	-11%	(\$0.0345)	No Reduction	(\$28)	(\$334)	-42%	
154 MW Combined Cycle (CC) - stand alone	154	50	0.000685	60%	(\$0.0294)	(\$43)	(\$24)	(\$285)	-36%	
215 MW CC - stand alone	215	50	0.000710	62%	(\$0.0345)	(\$49)	(\$28)	(\$334)	-42%	
215 MW CC - unit 1	215	50	0.000710	62%	(\$0.0334)	(\$47)	(\$27)	(\$324)	-41%	
215 MW CC - unit n	215	50	0.000710	62%	(\$0.0374)	(\$53)	(\$30)	(\$363)	-46%	
Molten Carbonate Fuel Cell	2	50	0.000636	56%	(\$0.0039)	(\$6)	(\$3)	(\$37)	-5%	
75 MW Combustion Turbine (CT) - stand alone	75	50	0.000498	43%	(\$0.0248)	(\$50)	(\$20)	(\$240)	-30%	
83 MW CT - stand alone	83	50	0.000248	22%	(\$0.0194)	(\$78)	(\$16)	(\$188)	-24%	
154 MW CT - stand alone	154	50	0.000490	43%	(\$0.0262)	(\$53)	(\$21)	(\$254)	-32%	
154 MW CT - unit 1	154	50	0.000490	43%	(\$0.0258)	(\$53)	(\$21)	(\$250)	-32%	
154 MW CT - unit n	154	50	0.000490	43%	(\$0.0281)	(\$57)	(\$23)	(\$272)	-34%	
Atmospheric Fluidized Bed Biomass	30	80	0.001145	100%	\$0.0150	\$13	\$12	\$145	18%	
Spreader Stoker Biomass (7.2)	7	80	0.001145	100%	\$0.0297	\$26	\$24	\$288	36%	
Spreader Stoker Biomass (57)	57	80	0.001145	100%	(\$0.0048)	(\$4)	(\$4)	(\$47)	-6%	
Whole Tree Biomass	100	80	0.001145	100%	(\$0.0246)	(\$21)	(\$20)	(\$238)	-30%	
Integrated Gasification Combined Cycle Biomass	100	80	0.001145	100%	(\$0.0050)	(\$4)	(\$4)	(\$49)	-6%	
Wind Turbine	10	20	0.001145	100%	\$0.0083	\$7	\$7	\$81	10%	
Fixed Flat Plate Photovoltaic (5)	5	20	0.001145	100%	\$0.2659	\$232	\$215	\$2,578	326%	
Fixed Flat Plate Photovoltaic (0.5)	0.5	20	0.001145	100%	\$0.3946	\$345	\$319	\$3,826	484%	
Fixed Flat Plate Photovoltaic (5), dispersed connection	5	20	0.001145	100%	\$0.2434	\$213	\$197	\$2,360	298%	
Fixed Flat Plate Photovoltaic (0.5), dispersed connection	0.5	20	0.001145	100%	\$0.3688	\$322	\$298	\$3,575	452%	

Table B.7 The Residential Incremental Cost of Reduced Emission Electricity

4-STATE AVERAGE							<u>Average Electricity Characteristics</u>		<u>Average Consumption</u>		
							Price (\$/kWh) =	\$0.086	Monthly =	717	
								lbs. CO2/kWh =	2.23	Yearly =	8,607
Consumer Electric Cost											
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase		
Coal Fluidized Bed Combustion	400	80	(0.000280)	-25%	(\$0.0453)	No Reduction	(\$32)	(\$390)	-52%		
Integrated Gasification Combined Cycle	500	80	0.000041	4%	(\$0.0411)	(\$1,000)	(\$29)	(\$354)	-48%		
Integrated Gasification Fuel Cell	400	80	0.000310	28%	(\$0.0321)	(\$104)	(\$23)	(\$277)	-37%		
Atmospheric Fluidized Bed Combustion	200	80	(0.000157)	-14%	(\$0.0392)	No Reduction	(\$28)	(\$338)	-45%		
154 MW Combined Cycle (CC) - stand alone	154	50	0.000655	59%	(\$0.0342)	(\$52)	(\$25)	(\$294)	-40%		
215 MW CC - stand alone	215	50	0.000680	61%	(\$0.0392)	(\$58)	(\$28)	(\$338)	-45%		
215 MW CC - unit 1	215	50	0.000680	61%	(\$0.0382)	(\$56)	(\$27)	(\$329)	-44%		
215 MW CC - unit n	215	50	0.000680	61%	(\$0.0422)	(\$62)	(\$30)	(\$363)	-49%		
Molten Carbonate Fuel Cell	2	50	0.000606	54%	(\$0.0086)	(\$14)	(\$6)	(\$74)	-10%		
75 MW Combustion Turbine (CT) - stand alone	75	50	0.000468	42%	(\$0.0295)	(\$63)	(\$21)	(\$254)	-34%		
83 MW CT - stand alone	83	50	0.000218	20%	(\$0.0241)	(\$111)	(\$17)	(\$208)	-28%		
154 MW CT - stand alone	154	50	0.000460	41%	(\$0.0310)	(\$67)	(\$22)	(\$267)	-36%		
154 MW CT - unit 1	154	50	0.000460	41%	(\$0.0305)	(\$66)	(\$22)	(\$263)	-35%		
154 MW CT - unit n	154	50	0.000460	41%	(\$0.0328)	(\$71)	(\$24)	(\$283)	-38%		
Atmospheric Fluidized Bed Biomass	30	80	0.001115	100%	\$0.0103	\$9	\$7	\$88	12%		
Spreader Stoker Biomass (7.2)	7	80	0.001115	100%	\$0.0250	\$22	\$18	\$215	29%		
Spreader Stoker Biomass (57)	57	80	0.001115	100%	(\$0.0096)	(\$9)	(\$7)	(\$82)	-11%		
Whole Tree Biomass	100	80	0.001115	100%	(\$0.0293)	(\$26)	(\$21)	(\$252)	-34%		
Integrated Gasification Combined Cycle Biomass	100	80	0.001115	100%	(\$0.0098)	(\$9)	(\$7)	(\$84)	-11%		
Wind Turbine	10	20	0.001115	100%	\$0.0036	\$3	\$3	\$31	4%		
Fixed Flat Plate Photovoltaic (5)	5	20	0.001115	100%	\$0.2612	\$234	\$187	\$2,248	303%		
Fixed Flat Plate Photovoltaic (0.5)	0.5	20	0.001115	100%	\$0.3899	\$350	\$280	\$3,356	452%		
Fixed Flat Plate Photovoltaic (5), dispersed connection	5	20	0.001115	100%	\$0.2386	\$214	\$171	\$2,054	276%		
Fixed Flat Plate Photovoltaic (0.5), dispersed connection	0.5	20	0.001115	100%	\$0.3640	\$326	\$261	\$3,133	422%		

Table B.8 The Industrial Incremental Cost of Reduced Emission Electricity

WISCONSIN			Average Electricity Characteristics				Average Consumption			
			Price (\$/kWh) =	\$0.037	Monthly =	391,046	lbs. CO2/kWh =	2.23	Yearly =	4,692,550
Consumer Electric Cost										
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase	
Coal Fluidized Bed Combustion	400	80	(0.000280)	-25%	\$0.0044	No Reduction	\$1,736	\$20,833	12%	
Integrated Gasification Combined Cycle	500	80	0.000041	4%	\$0.0087	\$211	\$3,388	\$40,653	24%	
Integrated Gasification Fuel Cell	400	80	0.000310	28%	\$0.0176	\$57	\$6,883	\$82,595	48%	
Atmospheric Fluidized Bed Combustion	200	80	(0.000157)	-14%	\$0.0105	No Reduction	\$4,111	\$49,327	29%	
154 MW Combined Cycle - single unit	154	50	0.000655	59%	\$0.0156	\$24	\$6,086	\$73,038	43%	
215 MW Combined Cycle - single unit	215	50	0.000680	61%	\$0.0105	\$15	\$4,110	\$49,317	29%	
215 MW Combined Cycle - 1st of multiple unit	215	50	0.000680	61%	\$0.0116	\$17	\$4,526	\$54,306	32%	
215 MW Combined Cycle - nth of multiple unit	215	50	0.000680	61%	\$0.0076	\$11	\$2,954	\$35,444	21%	
Molten Carbonate Fuel Cell	2	50	0.000606	54%	\$0.0411	\$68	\$16,087	\$193,042	112%	
75 MW Combustion Turbine - single unit	75	50	0.000468	42%	\$0.0202	\$43	\$7,906	\$94,871	55%	
83 MW Combustion Turbine - single unit	83	50	0.000218	20%	\$0.0256	\$118	\$10,020	\$120,238	70%	
154 MW Combustion Turbine - single unit	154	50	0.000460	41%	\$0.0188	\$41	\$7,343	\$88,115	51%	
154 MW Combustion Turbine - 1st of multiple unit	154	50	0.000460	41%	\$0.0192	\$42	\$7,518	\$90,216	53%	
154 MW Combustion Turbine - nth of multiple unit	154	50	0.000460	41%	\$0.0169	\$37	\$6,609	\$79,306	46%	
Atmospheric Fluidized Bed Combustion - Biomass	30	80	0.001115	100%	\$0.0600	\$54	\$23,460	\$281,524	164%	
Spreader Stoker Biomass	7	80	0.001115	100%	\$0.0747	\$67	\$29,228	\$350,739	204%	
Spreader Stoker Biomass	57	80	0.001115	100%	\$0.0402	\$36	\$15,709	\$188,512	110%	
Whole Tree Biomass	100	80	0.001115	100%	\$0.0204	\$18	\$7,986	\$95,831	56%	
Integrated Gasification Combined Cycle - Biomass	100	80	0.001115	100%	\$0.0400	\$36	\$15,630	\$187,557	109%	
Wind Turbine	10	20	0.001115	100%	\$0.0533	\$48	\$20,857	\$250,288	146%	
5 MW Flat Plate Photovoltaic	5	20	0.001115	100%	\$0.3109	\$279	\$121,587	\$1,459,050	850%	
0.5 MW Flat Plate Photovoltaic	0.5	20	0.001115	100%	\$0.4396	\$394	\$171,903	\$2,062,842	1201%	
5 MW Fixed Flat Plate Photovoltaic - dispersed connection	5	20	0.001115	100%	\$0.2884	\$259	\$112,773	\$1,353,271	788%	
0.5 MW Fixed Flat Plate Photovoltaic - dispersed connection	0.5	20	0.001115	100%	\$0.4138	\$371	\$161,798	\$1,941,581	1130%	

Table B.9 The Industrial Incremental Cost of Reduced Emission Electricity

ILLINOIS			Average Electricity Characteristics				Customer Average kWh		
			Price (\$/kWh) =	\$0.052	Monthly =	694,307	lbs. CO2/kWh =	2.17	Yearly =
			tons CO2/kWh = 0.001085				Consumer Electric Cost		
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase
Coal Fluidized Bed Combustion	400	80	(0.000310)	-29%	(\$0.0114)	No Reduction	(\$7,888)	(\$94,652)	-22%
Integrated Gasification Combined Cycle	500	80	0.000011	1%	(\$0.0071)	(\$644)	(\$4,955)	(\$59,460)	-14%
Integrated Gasification Fuel Cell	400	80	0.000280	26%	\$0.0018	\$6	\$1,251	\$15,008	3%
Atmospheric Fluidized Bed Combustion	200	80	(0.000187)	-17%	(\$0.0053)	No Reduction	(\$3,672)	(\$44,061)	-10%
154 MW Combined Cycle - single unit	154	50	0.000625	58%	(\$0.0002)	(\$0)	(\$163)	(\$1,961)	-0%
215 MW Combined Cycle - single unit	215	50	0.000650	60%	(\$0.0053)	(\$8)	(\$3,673)	(\$44,078)	-10%
215 MW Combined Cycle - 1st of multiple unit	215	50	0.000650	60%	(\$0.0042)	(\$6)	(\$2,935)	(\$35,219)	-8%
215 MW Combined Cycle - nth of multiple unit	215	50	0.000650	60%	(\$0.0082)	(\$13)	(\$5,726)	(\$68,710)	-16%
Molten Carbonate Fuel Cell	2	50	0.000576	53%	\$0.0253	\$44	\$17,592	\$211,109	48%
75 MW Combustion Turbine - single unit	75	50	0.000438	40%	\$0.0044	\$10	\$3,067	\$36,805	8%
83 MW Combustion Turbine - single unit	83	50	0.000188	17%	\$0.0098	\$52	\$6,820	\$81,844	19%
154 MW Combustion Turbine - single unit	154	50	0.000430	40%	\$0.0030	\$7	\$2,067	\$24,809	6%
154 MW Combustion Turbine - 1st of multiple unit	154	50	0.000430	40%	\$0.0034	\$8	\$2,378	\$28,538	7%
154 MW Combustion Turbine - nth of multiple unit	154	50	0.000430	40%	\$0.0011	\$3	\$764	\$9,168	2%
Atmospheric Fluidized Bed Combustion - Biomass	30	80	0.001085	100%	\$0.0442	\$41	\$30,684	\$368,209	84%
Spreader Stoker Biomass	7	80	0.001085	100%	\$0.0589	\$54	\$40,925	\$491,101	112%
Spreader Stoker Biomass	57	80	0.001085	100%	\$0.0244	\$22	\$16,922	\$203,066	47%
Whole Tree Biomass	100	80	0.001085	100%	\$0.0046	\$4	\$3,209	\$38,508	9%
Integrated Gasification Combined Cycle - Biomass	100	80	0.001085	100%	\$0.0242	\$22	\$16,781	\$201,370	46%
Wind Turbine	10	20	0.001085	100%	\$0.0375	\$35	\$26,062	\$312,749	72%
5 MW Flat Plate Photovoltaic	5	20	0.001085	100%	\$0.2951	\$272	\$204,910	\$2,458,921	563%
0.5 MW Flat Plate Photovoltaic	0.5	20	0.001085	100%	\$0.4238	\$391	\$294,247	\$3,530,961	809%
5 MW Fixed Flat Plate Photovoltaic - dispersed connection	5	20	0.001085	100%	\$0.2726	\$251	\$189,259	\$2,271,109	520%
0.5 MW Fixed Flat Plate Photovoltaic - dispersed connection	0.5	20	0.001085	100%	\$0.3980	\$367	\$276,305	\$3,315,662	759%

Table B.10 The Industrial Incremental Cost of Reduced Emission Electricity

IOWA			Average Electricity Characteristics				Customer Average kWh		
			Price (\$/kWh) =	\$0.039	Monthly =	31,090	lbs. CO2/kWh =	2.29	Yearly =
			Consumer Electric Cost						
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase
Coal Fluidized Bed Combustion	400	80	(0.000250)	-22%	\$0.0019	No Reduction	\$60	\$724	5%
Integrated Gasification Combined Cycle	500	80	0.000071	6%	\$0.0062	\$87	\$192	\$2,299	16%
Integrated Gasification Fuel Cell	400	80	0.000340	30%	\$0.0151	\$44	\$470	\$5,634	39%
Atmospheric Fluidized Bed Combustion	200	80	(0.000127)	-11%	\$0.0080	No Reduction	\$249	\$2,989	20%
154 MW Combined Cycle - single unit	154	50	0.000685	60%	\$0.0131	\$19	\$406	\$4,874	33%
215 MW Combined Cycle - single unit	215	50	0.000710	62%	\$0.0080	\$11	\$249	\$2,988	20%
215 MW Combined Cycle - 1st of multiple unit	215	50	0.000710	62%	\$0.0091	\$13	\$282	\$3,385	23%
215 MW Combined Cycle - nth of multiple unit	215	50	0.000710	62%	\$0.0051	\$7	\$157	\$1,885	13%
Molten Carbonate Fuel Cell	2	50	0.000636	56%	\$0.0386	\$61	\$1,201	\$14,415	99%
75 MW Combustion Turbine - single unit	75	50	0.000498	43%	\$0.0177	\$36	\$551	\$6,610	45%
83 MW Combustion Turbine - single unit	83	50	0.000248	22%	\$0.0231	\$93	\$719	\$8,627	59%
154 MW Combustion Turbine - single unit	154	50	0.000490	43%	\$0.0163	\$33	\$506	\$6,073	42%
154 MW Combustion Turbine - 1st of multiple unit	154	50	0.000490	43%	\$0.0167	\$34	\$520	\$6,240	43%
154 MW Combustion Turbine - nth of multiple unit	154	50	0.000490	43%	\$0.0144	\$29	\$448	\$5,373	37%
Atmospheric Fluidized Bed Combustion - Biomass	30	80	0.001145	100%	\$0.0575	\$50	\$1,787	\$21,450	147%
Spreader Stoker Biomass	7	80	0.001145	100%	\$0.0722	\$63	\$2,246	\$26,953	185%
Spreader Stoker Biomass	57	80	0.001145	100%	\$0.0377	\$33	\$1,171	\$14,055	96%
Whole Tree Biomass	100	80	0.001145	100%	\$0.0179	\$16	\$557	\$6,686	46%
Integrated Gasification Combined Cycle - Biomass	100	80	0.001145	100%	\$0.0375	\$33	\$1,165	\$13,979	96%
Wind Turbine	10	20	0.001145	100%	\$0.0508	\$44	\$1,581	\$18,967	130%
5 MW Flat Plate Photovoltaic	5	20	0.001145	100%	\$0.3084	\$269	\$9,589	\$115,070	789%
0.5 MW Flat Plate Photovoltaic	0.5	20	0.001145	100%	\$0.4371	\$382	\$13,590	\$163,074	1118%
5 MW Fixed Flat Plate Photovoltaic - dispersed connection	5	20	0.001145	100%	\$0.2859	\$250	\$8,888	\$106,660	731%
0.5 MW Fixed Flat Plate Photovoltaic - dispersed connection	0.5	20	0.001145	100%	\$0.4113	\$359	\$12,786	\$153,433	1052%

Table B.11 The Industrial Incremental Cost of Reduced Emission Electricity

MINNESOTA			Average Electricity Characteristics				Customer Average kWh		
			Price (\$/kWh) =	\$0.043	Monthly =	226,420	lbs. CO2/kWh =	2.32	Yearly =
			Consumer Electric Cost						
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase
Coal Fluidized Bed Combustion	400	80	(0.000235)	-20%	(\$0.0016)	No Reduction	(\$353)	(\$4,240)	-4%
Integrated Gasification Combined Cycle	500	80	0.000086	7%	\$0.0027	\$31	\$603	\$7,236	6%
Integrated Gasification Fuel Cell	400	80	0.000355	31%	\$0.0116	\$33	\$2,627	\$31,521	27%
Atmospheric Fluidized Bed Combustion	200	80	(0.000112)	-10%	\$0.0045	No Reduction	\$1,022	\$12,258	11%
154 MW Combined Cycle - single unit	154	50	0.000700	60%	\$0.0096	\$14	\$2,166	\$25,988	22%
215 MW Combined Cycle - single unit	215	50	0.000725	63%	\$0.0045	\$6	\$1,021	\$12,253	11%
215 MW Combined Cycle - 1st of multiple unit	215	50	0.000725	63%	\$0.0056	\$8	\$1,262	\$15,142	13%
215 MW Combined Cycle - nth of multiple unit	215	50	0.000725	63%	\$0.0016	\$2	\$352	\$4,220	4%
Molten Carbonate Fuel Cell	2	50	0.000651	56%	\$0.0351	\$54	\$7,956	\$95,471	82%
75 MW Combustion Turbine - single unit	75	50	0.000513	44%	\$0.0142	\$28	\$3,219	\$38,629	33%
83 MW Combustion Turbine - single unit	83	50	0.000263	23%	\$0.0196	\$75	\$4,443	\$53,317	46%
154 MW Combustion Turbine - single unit	154	50	0.000505	44%	\$0.0128	\$25	\$2,893	\$34,717	30%
154 MW Combustion Turbine - 1st of multiple unit	154	50	0.000505	44%	\$0.0132	\$26	\$2,994	\$35,934	31%
154 MW Combustion Turbine - nth of multiple unit	154	50	0.000505	44%	\$0.0109	\$22	\$2,468	\$29,617	26%
Atmospheric Fluidized Bed Combustion - Biomass	30	80	0.001160	100%	\$0.0540	\$47	\$12,225	\$146,703	127%
Spreader Stoker Biomass	7	80	0.001160	100%	\$0.0687	\$59	\$15,565	\$186,779	161%
Spreader Stoker Biomass	57	80	0.001160	100%	\$0.0342	\$29	\$7,737	\$92,849	80%
Whole Tree Biomass	100	80	0.001160	100%	\$0.0144	\$12	\$3,265	\$39,185	34%
Integrated Gasification Combined Cycle - Biomass	100	80	0.001160	100%	\$0.0340	\$29	\$7,691	\$92,295	80%
Wind Turbine	10	20	0.001160	100%	\$0.0473	\$41	\$10,718	\$128,617	111%
5 MW Flat Plate Photovoltaic	5	20	0.001160	100%	\$0.3049	\$263	\$69,042	\$828,504	716%
0.5 MW Flat Plate Photovoltaic	0.5	20	0.001160	100%	\$0.4336	\$374	\$98,175	\$1,178,106	1018%
5 MW Fixed Flat Plate Photovoltaic - dispersed connection	5	20	0.001160	100%	\$0.2824	\$243	\$63,938	\$767,257	663%
0.5 MW Fixed Flat Plate Photovoltaic - dispersed connection	0.5	20	0.001160	100%	\$0.4078	\$352	\$92,325	\$1,107,895	957%

Table B.12 The Industrial Incremental Cost of Reduced Emission Electricity

4-STATE AVERAGE			Average Electricity Characteristics				Customer Ave kWh			
			Price (\$/kWh) =	\$0.051	Monthly =	327,398	lbs. CO2/kWh =	2.23	Yearly =	3,928,778
			Consumer Electric Cost							
Technology	Nominal Capacity @ 90F (MW)	Capacity Factor	CO2 Reduction vs. Average Electric Mix (tons/kWh)	CO2 Reduction vs. Average Electric Mix	Incremental Cost of Electricity (\$/kWh)	Incremental Cost of CO2 Reduction (\$/ton)	Average Monthly Cost	Average Yearly Cost	Percent Cost Increase	
Coal Fluidized Bed Combustion	400	80	(0.000280)	-25%	(\$0.0099)	No Reduction	(\$3,232)	(\$38,785)	-19%	
Integrated Gasification Combined Cycle	500	80	0.000041	4%	(\$0.0056)	(\$137)	(\$1,849)	(\$22,191)	-11%	
Integrated Gasification Fuel Cell	400	80	0.000310	28%	\$0.0033	\$11	\$1,077	\$12,924	6%	
Atmospheric Fluidized Bed Combustion	200	80	(0.000157)	-14%	(\$0.0038)	No Reduction	(\$1,244)	(\$14,929)	-7%	
154 MW Combined Cycle - single unit	154	50	0.000655	59%	\$0.0013	\$2	\$410	\$4,923	2%	
215 MW Combined Cycle - single unit	215	50	0.000680	61%	(\$0.0038)	(\$6)	(\$1,245)	(\$14,937)	-7%	
215 MW Combined Cycle - 1st of multiple unit	215	50	0.000680	61%	(\$0.0027)	(\$4)	(\$897)	(\$10,760)	-5%	
215 MW Combined Cycle - nth of multiple unit	215	50	0.000680	61%	(\$0.0068)	(\$10)	(\$2,213)	(\$26,552)	-13%	
Molten Carbonate Fuel Cell	2	50	0.000606	54%	\$0.0268	\$44	\$8,783	\$105,395	53%	
75 MW Combustion Turbine - single unit	75	50	0.000468	42%	\$0.0059	\$13	\$1,934	\$23,203	12%	
83 MW Combustion Turbine - single unit	83	50	0.000218	20%	\$0.0113	\$52	\$3,703	\$44,441	22%	
154 MW Combustion Turbine - single unit	154	50	0.000460	41%	\$0.0045	\$10	\$1,462	\$17,546	9%	
154 MW Combustion Turbine - 1st of multiple unit	154	50	0.000460	41%	\$0.0049	\$11	\$1,609	\$19,305	10%	
154 MW Combustion Turbine - nth of multiple unit	154	50	0.000460	41%	\$0.0026	\$6	\$848	\$10,171	5%	
Atmospheric Fluidized Bed Combustion - Biomass	30	80	0.001115	100%	\$0.0457	\$41	\$14,956	\$179,476	90%	
Spreader Stoker Biomass	7	80	0.001115	100%	\$0.0604	\$54	\$19,785	\$237,425	119%	
Spreader Stoker Biomass	57	80	0.001115	100%	\$0.0259	\$23	\$8,467	\$101,603	51%	
Whole Tree Biomass	100	80	0.001115	100%	\$0.0061	\$5	\$2,000	\$24,006	12%	
Integrated Gasification Combined Cycle - Biomass	100	80	0.001115	100%	\$0.0257	\$23	\$8,400	\$100,803	50%	
Wind Turbine	10	20	0.001115	100%	\$0.0390	\$35	\$12,777	\$153,323	77%	
5 MW Flat Plate Photovoltaic	5	20	0.001115	100%	\$0.2966	\$266	\$97,112	\$1,165,344	583%	
0.5 MW Flat Plate Photovoltaic	0.5	20	0.001115	100%	\$0.4253	\$381	\$139,238	\$1,670,861	835%	
5 MW Fixed Flat Plate Photovoltaic - dispersed connection	5	20	0.001115	100%	\$0.2741	\$246	\$89,732	\$1,076,782	538%	
0.5 MW Fixed Flat Plate Photovoltaic - dispersed connection	0.5	20	0.001115	100%	\$0.3994	\$358	\$130,778	\$1,569,337	785%	